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JOHN F. KELLY, EDITOR

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Mr. W. E. Miller, Electrical and Mechanical Superintendent, Bethlehem Steel Company, Johnstown, Pa., President of the Association of Iron and Steel Electrical Engineers for the year 1933-1934.

THE PRESIDENT'S MESSAGE

Another year has rolled along in A. I. & S. E. E. history. Much was accomplished during the year just passed. Many valuable papers and discussions were presented before crowded technical sessions in our five sections. These papers and discussions were valuable additions to our Proceedings and represent a highly successful year of technical effort. Despite this very successful year from a technical standpoint, it was a particularly trying year for the men responsible for the management and operation of the Association. Quick decisions had to be made; plans had to be revamped to fit in with the economic pattern. It was during this trying year that we, as members of the Association, realized just how fortunate we were in having a man as Chief Executive of our organization of the caliber of our Past President, who has just finished his term. His courage, initiative and judgment were ever helpful to the men responsible for the activities of the A. I. & S. E. E. His term as President will go down in our records as one of the most trying of our history and it is my earnest hope that I may be able to attend to my duties as President of our Society as well as he did in those difficult depression days.

It is with a tremendous sense of security that I, as President of the Association, look over the Board of Directors which you have elected to help and advise me through the coming year. The men you have selected are typical of our great Industry. They are men of varied experience, and their ideas, opinions and experiences will be especially valuable to me during the coming year. This Board of Directors, which you have elected, I know will co-operate with me in making this next year a highly successful year for the Association. One of our first and very important duties will be the appointment of the National Committees for 1933-1934.

The President and Board of Directors find it a difficult task to select National Committeemen. We particularly desire to get just the right men for the proper committees. We have twenty-two National Committees, embracing five different divisions—Mechanical, Electrical, Combustion, Lubrication and Safety Engineering. With the co-operation of the membership, we can make the functioning of these committees very effective and we are soliciting the aid of the membership in completing the personnel of these various committees. If any member desires to serve on any particular committee, might I suggest that he drop me a line at the Association's headquarters in Pittsburgh and he can rest assured that his request will be given every consideration. We need your support and co-operation and we invite your suggestions as to papers, meetings, programs, campaigns, etc.

The Campaign for "New Uses for Steel" will be ended in October, but may I take this opportunity to request that, although the Campaign will be closed, let us always be on the alert to further the Uses of Steel, whether it be in the mill, home or highway. Announcement of the winners of the "New Uses for Steel" campaign will be made at the 29th Convention and Iron and Steel Exposition, which will be held in Pittsburgh on October 17, 18, and 19, 1933.

This Convention and Exposition promises to be one of the best we have ever held. A very attractive program has been arranged on subjects of great interest to steel mill executives and engineers. The following is a tentative program of the subjects which will be presented and discussed at the Convention:

Cold Mill Practices

Anti-Friction Bearings

Fundamentals of Open Hearth Design

Electrical, Mechanical, Lubrication, Combustion Developments in the Iron and Steel Industry.

Improvements in Steel Plant Furnace Design

Oil Fired Soaking Pits

Pair and Pack Heating in Connection with Sheet and Tin Mill Furnaces

Electric Furnaces for Annealing Strip, Sheet and Tin Plate

Normalizing Furnaces in Connection with Sheet and Tin Mills

Electric Welded Frameless Steel Houses

Developments in Electric Welded Fabricated Rolled Steel Products

Present Operating Status of Electric Welding in the Steel Industry.

Rectification of Electrical Power in Connection with Cleaning Blast Furnace Gas

Mechanical and Lubrication Problems in Connection with Reduction Gear Sets

Developments in Electrical Apparatus in Connection with Strip, Sheet and Tin Mills.

The Iron and Steel Exposition will display all the latest developments in the mechanical, electrical, combustion, lubrication and safety apparatus used in the Iron and Steel Industry.

Make your plans now to attend the Technical Sessions of the Convention and attend the Iron and Steel Exposition; also, have your assistants and department heads attend and take part in the activities. Hear the papers and participate in the discussions.

This Convention and Exposition, as well as all other Association activities, are for your benefit. It is your Association. You have done me the honor of electing me President and, as President, may I again ask for your co-operation and support and we will continue to make the Association influence of lasting benefit to our great Industry.

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Cold Rolling Practices

By LLOYD JONES
Manager, E. W. Bliss Company, Salem, Ohio

Presented before the A. I. & S. E. E. at Salem, Ohio, May, 1933

Today you have inspected what is believed to be the most powerful Mill of the Backed-up Type designed especially for Heavy Duty Cold Rolling Services. This Mill, which one of our friends has been kind enough to christen "The Super-Cold Mill," possesses a number of unique features. It might be well, at this time, before proceeding with the main subject of the paper, to discuss a few of these.

Figures 1 and 2 show the mill erected in Horizontal Position. The arrangement is one form of Backed-up Type, known as Four-High.

The Working Rolls are made of hardened forged steel, approximately 100 scleroscope, about 20" in diameter x 84" long. The Backing Rolls are steel castings approximately 56" in diameter x 84" long. The Housings are of a new type, never used heretofore, being made of laminated steel forgings, which, when assembled, give a post section of 31" x 34", or an area of 1054 square inches. The weight of the assembled forgings in each housing being approximately 125 tons.

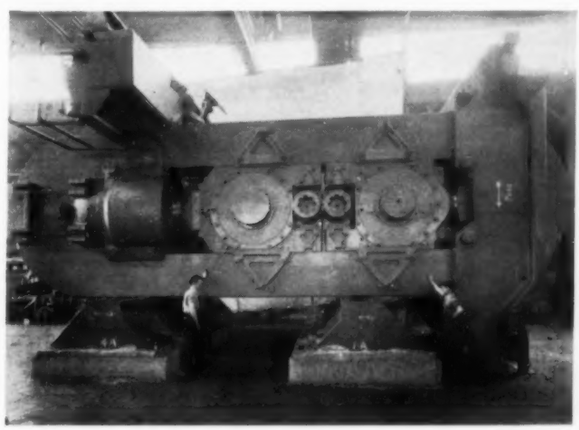


FIG. 1.

In order to secure a simple link design for the housing, a new type of screwdown was designed. As the pressures on this Mill are apt to reach a total of 12,000,000 pounds or 6,000 tons, the screw mechanism was made exceedingly powerful. See Figure 3.

The screws are 28" in diameter, operating in nuts made of high tensile bronze having ultimate strength in excess of 110,000 pounds. In order to secure favorable aligning conditions for the large bearings, double spherical shaped washers were placed under the bottom bearings, as well as those supported by the screws.

The forged steel housings are fitted with cast steel shoes which support the entire structure on the usual type of bed plate. In order to prevent any localized stresses in the housings we have removed practically all projections, going even to the extent of supporting the screwdown mechanism by means of links from the top of the housings.

Figure 4 shows a cross-section through the screwdown. To exert the enormous pressure required and keep the mechanism within the confined limitations and at the same time to make all parts easy

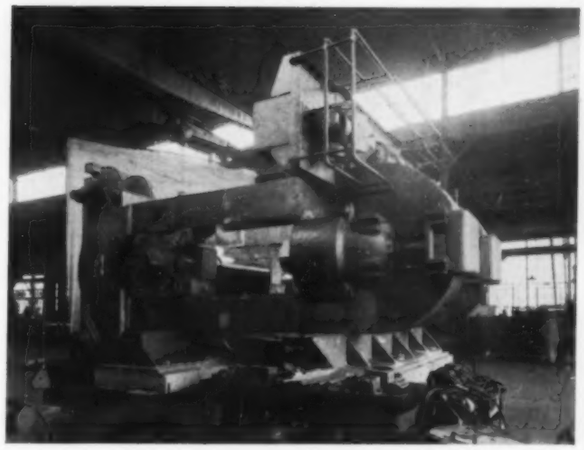


FIG. 2.

for inspection and dismantling was no easy task. A double reduction worm gear type was decided upon. Both worms are single thread, giving the total ratio of approximately 2000 to 1, being equivalent of approximately one-quarter thousandths of an inch movement of the roll for one revolution of the motor. You will note that Roller Bearings are used throughout, not only to reduce friction but also to hold the gears in accurate alignment.

The main castings forming the screwdown frame are wedged into place instead of being bolted. Throughout we have worked on the principle that it is foolish to design a housing for a specific purpose and then destroy its efficiency by cutting it up with a lot of bolt holes, etc. The construction also acts as a binder for the laminations forming the housing, tending to prevent any separating forces that might exist.

You will note that the main worm which has to take considerable end thrust is held in place by split rings fitted into recesses. The end engaging the first reduction is fluted. In order to remove these worms it is only necessary to remove one bolt and this bolt is at no time under any stress.

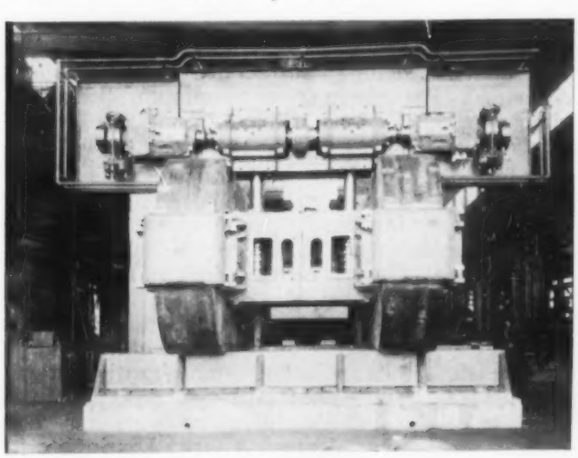


FIG. 3.

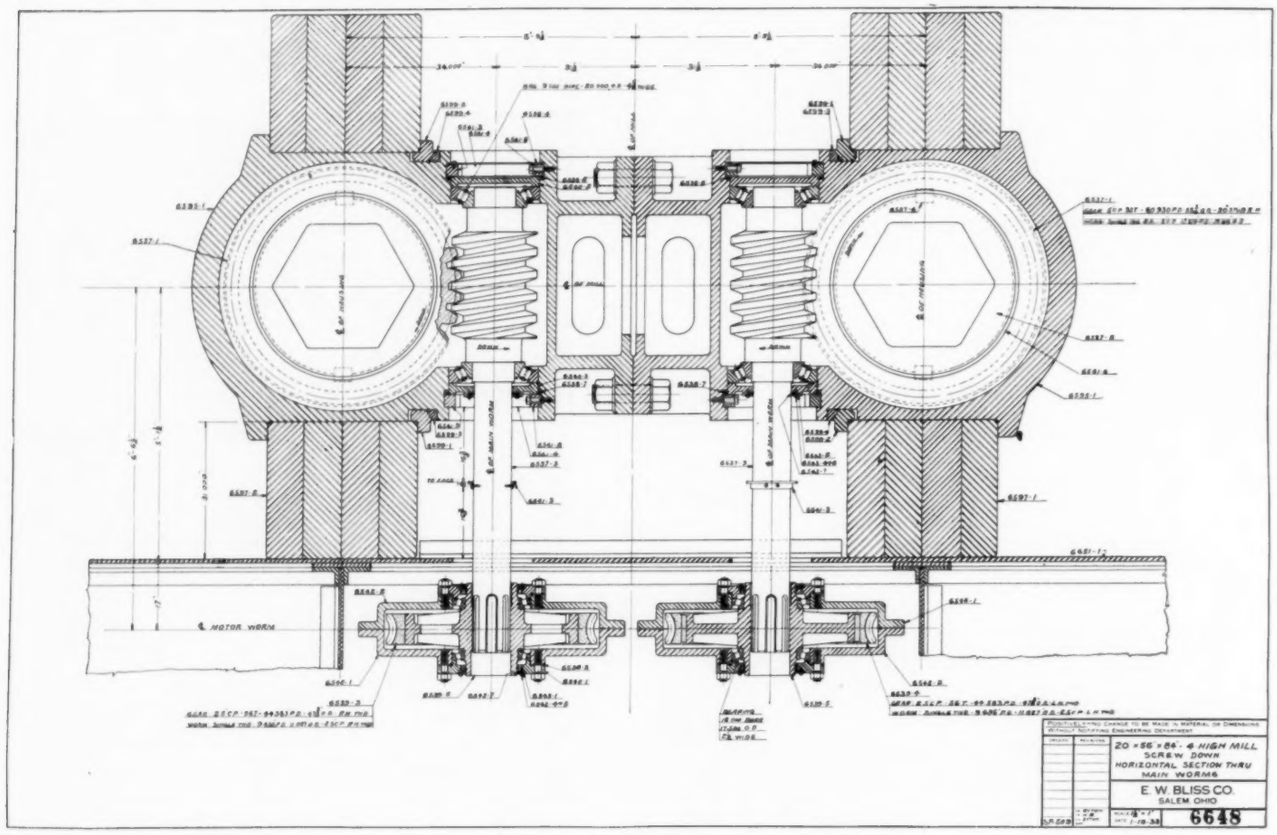


FIG. 4.

Figure 5 shows the arrangement of bearings for both the working rolls and the backing rolls. The bearings for the small rolls are not under great stress and as far as mills generally are concerned, give little or no trouble. The large bearings for the backing rolls are of extreme importance and a great deal of study was given as to their design, construction and material. The dimensions of these bearings are 30" bore, 51" outside diameter x 25½" width. They were furnished by the Bantam Ball Bearing Company of South Bend, Ind. Both the rollers and the races are made of SAE52-100 Steel, furnished by the Illinois Steel Company. They are the largest bearings made to date of a natural hardening steel. The analysis being: Carbon .95 - 1.10, Manganese .20 - .50, Phosphorus .03 maximum, Sulphur .035 maximum, Chromium 1.20 - 1.50.

This question of Roller Bearings, is such a vital one to both the Mill Manufacturer and the Steel Plants, that perhaps you will pardon me if we take a few more minutes of your time on this question.

Some months ago while on the witness stand in a court trial, the Attorney tried to make considerable capital out of my statement that when we built the first large Backed-up Mill, for the International Nickel Company, at Huntington, we were not able at that time to secure bearings of satisfactory size and manufacture. That Mill was designed in 1923. In spite of the fact that great progress has recently been made in manufacturing large bearings and we have been using bearings on many mills up to the present time, their performance has not been entirely satisfactory. The Industry has had many failures and replacements, and only recently have they awakened to the fact that the life of the bearing in many cases, is such as to make the cost per ton of steel rolled excessive. In the construction of this mill therefore, the author determined to do some pioneering in the interests of all, including the Bearing Manufacturers.

For the working rolls of Cold Mills there has been developed and successfully used the hardened steel work roll which is not a case hardened proposition, but made of a natural or through hardened steel. The crushing loads on the Work Rolls are exactly the same as the loads on the backing roll bearings. No one would think of using a case hardened steel work roll for cold rolling. As most of the roller bearing failures had been due to spalling of the rollers and races, the author believes that a material similar to the work rolls should be used in the construction of the bearings. In spite of the statements of a number of people that large taper roller bearings could not be successfully manufactured with this kind of steel, we finally found a concern willing to undertake the problem. You have seen these bearings on exhibition today and if their performance comes up to our expectations, the Mill user will be considerably benefited as he will secure better operating conditions and the Roller Bearing Manufacturer will be benefited as he will produce a better product at a lower cost.

The design of the bearing is shown in Figure 6. It is of the two-row type, the rollers being spaced apart by means of bronze cages. By removing the outer center section, the dismantling of the bearing is readily accomplished without destroying the cages. The bearing is also designed so that the cages may be removed and full complement of rollers used.

In order to obtain the hardness on the various surfaces where required and at other places, keep the metal as ductile as possible so as to prevent breakage during hardening and in use; masks were applied at various points.

We wish to say at this time that our entire object in regards to these bearings has not been to show any preference in regards to roller bearing manufacturers, but to lift the art of roller bearing manufacture to a higher plane and we hope that everyone will ultimately be benefited.

In many instances the size of Mills have been increased for no other reason than to secure space to accommodate bearings of sufficient capacities. At the rate we were going, we were fast reaching a point where the rolls would become of such a large diameter that their manufacture is accomplished only with extreme difficulty. In fact, rolls of 100" diameter were coming up on the horizon.

The only logical thing to do was not to indefinitely increase the size of the Mills, but to make better bearings. Not only to make them better, but also change their design so as to secure greater carrying capacity within a given space. Also, to mount them in such a manner as to get a proper distribution of loads so as to increase their useful life. You must remember that a bearing is no stronger than its **weakest roller**—as a chain is no stronger than its weakest link.

Before leaving this Mill, let us return for a few minutes to the Steel Housings. The eight (8) rough forgings used in this connection were furnished by the Carnegie Steel Company, and were made in the Armour Plate Department of their Homestead Plant. It was the finest exhibition of forging and flame cutting that I have ever seen, all eight of the slabs used in construction were furnished within approximately 30 days time. A most remarkable delivery performance as compared to steel castings. As the sections were shipped singly, ordinary flat cars could be used for transportation and it simplified handling in our shops a great deal. We, in turn, will ship these housings to their destination in halves, making handling and erecting comparatively easy in the Steel Plant.

As each section was forged from a large ingot, the grain structure through the entire cross-section of the housing is extremely uniform. This is of vital importance in Mills rolling wide widths, as it is very desirable that the two housings shall have practically uniform elongation under the rolling stresses. The absence of segregation, casting strains, blow holes combined with the manufacturing and transportation advantages, has convinced us during the construction of this Mill, that the forged steel housing is far superior to the steel casting, especially in large units.

It was not many years ago, when a rolling mill was considered a very rough piece of workmanship.

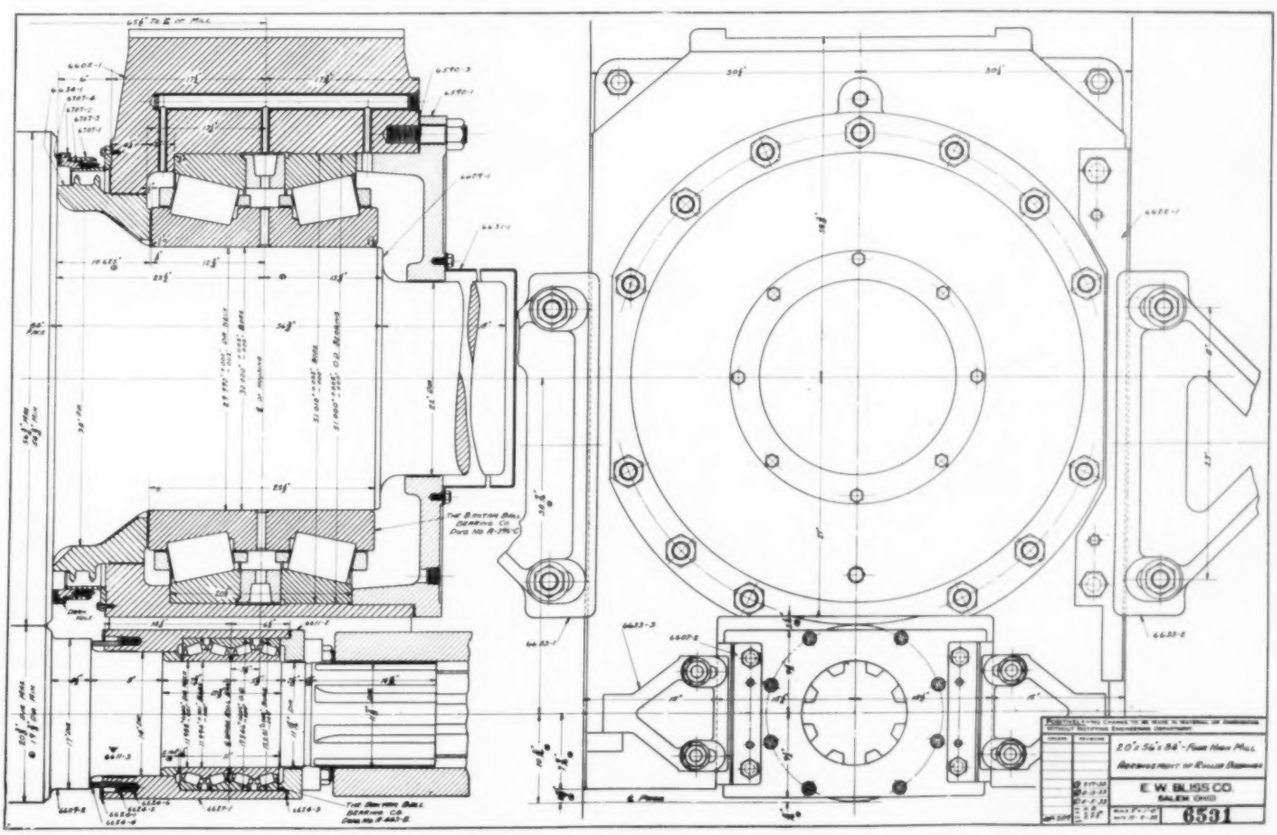


FIG. 5.

With the constantly increasing demands for better finished steel of more accurate gauges it was found necessary to improve the design and workmanship of the mills. It may astonish you to know that the machine work on this large mill is in most places, where required, to within a tolerance of a few thousandths of an inch.

The Mill, which you have inspected today, stands approximately at the end of a Century of the Art of Cold Rolling materials. The topic given me to speak upon, was—**"Cold Rolling Practices."** Perhaps at this time it might be well to make a few remarks with reference to the historical background of what has today developed into a wonderful industry; and which bids fair to rival in tonnage and in importance the hot rolling of metals. So much has been accomplished by the pioneers in this field and so little has been spread upon the records regarding their achievements that few are acquainted with the progress made. Probably the best treatise on the subject has been written by Stephen Badlam in his **"Evolution of the Wide Strip Mill"** 1927, and the **"Cold Rolling of Strip"** 1930. Mr. Badlam, by his association with the Industry, combined with his writing ability, is wonderfully fitted to compile such a history and hope that he will someday continue his researches and elaborate considerably on the past Cold Rolling Achievements and thus familiarize everyone with the "Prior Art."

The beginning of Cold Rolling in the Non-Ferrous Industry, is almost an antiquity. As far as the Steel Industry is concerned in America, the early pioneers started during the decade of 1870 to 1880. From then on, the growth in tonnage cold rolled and in the number of cold rolling establishments increased so rapidly that by 1918 there were probably over one hundred establishments.

These pioneers developed the principles, processes and mechanical equipment to such an extent, so that by 1918 there was practically nothing left for us to do, except to modify and improve the structure which they had erected.

Here is a List of their accomplishments Prior to 1918.

1. Hardened Forged Steel Rolls.
2. Advantage of small rolls for reducing wide widths, to thin gauges.
3. Large Backing Rolls for supporting small reducing rolls.
4. Advantages of Anti-friction Bearings.
5. Looping and Tandem Rolling.
6. Reversing Rolling.
7. Use of Tension Reels.
8. Advantage of rolling under tension in Continuous Mills.
9. Shaping of Rolls.
10. Lubrication of Strip.
11. Cooling of Rolls and Strip.
12. Backed-up Mills in Tandem.
13. Rolling shapes other than flat material.
14. Drawing material through rolling dies having Anti-friction mounting.
15. Tin and Zinc Coated Strips.
16. Wide thin gauge material in long widths.

Most of these pioneers have passed along to their reward; a few however, remain and perhaps there could be no more fitting occasion than this to mention at least one, who by his achievements, should forever remain upon the historical pages of the Cold Rolling Industry. I refer to D. A. Keating, the veteran who served under Wilmot & Hobbs, The American Tube and Stamping Company, and is now connected with the Stanley Works. These pioneers in the Strip Industry had a difficult road to travel as they had to compete with the Copper and Brass Industry, and be prepared to furnish an extremely wide range of product in small tonnages. The business in the early days, up to 1918 might be termed more or less, a "Jobbing Business," as they were called upon to furnish strip in widths from ⅛" to 24", in thickness from ¼" down to a few thousandths of an inch, and of hardness range, from dead soft through the various degrees to full hard. It is true that here and there a few were specializing upon one or two products, but, of the Industry in general, the above is true. This meant that the equipment of the plant and the practice in general was adopted more or less to the demands of the Trade. They knew the advantages of practically all of the factors which we stress so heavily today, but could not always apply them to their business, due to the small tonnages involved. Perhaps an example here will demonstrate that condition. About 1916, or probably earlier, the Morris & Bailey Plant, decided to install a Tandem Mill in order to produce the various demands of the Trade, the total cold reduction of

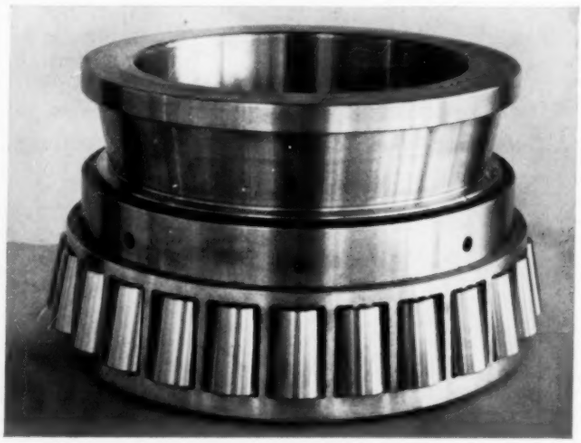


FIG. 6.

the strips in percent ranging from a minimum of 17% to a maximum of 70%. The examples specified for the mill were as follows:

.109	— .032	—	70%
.109	— .065	—	40%
.109	— .083	—	24%
.120	— .100	—	17%
.065	— .022	—	66%
.049	— .035	—	29%

The speed of the finishing mill was set at 275 feet per minute as this was the most convenient speed for the man to catch the end of the strip inserting it into the end of the reel, also it was a convenient speed for him to gauge while the strip was being rolled.

You sometimes hear people make remarks that the old mills were not capable of doing more than 40 to 50% reduction. This is not true. The mills were capable of doing more, but the demands of the Trade in regards to temper-surface, etc., did not

generally call for more reduction. Perhaps another example might serve to illustrate conditions, and the methods of rolling for supplying the various tempers and surfaces demanded.

For Rolling Full Hard Temper Material

.380 — .250 — 34%
.165 — .093 — 44%
.120 — .062 — 48%

For Rolling Half Hard Temper Material

.324 — .250 — 23%
.165 — .125 — 24%
.083 — .062 — 25%

For Rolling Quarter Hard Temper and Dead Soft Material

.109 — .031 — 71½%
.083 — .025 — 70%
.065 — .015 — 77%

The Trade Requirements in this particular case were as follows:
20% of the output ranged from 20 to 25% reduction.
25% of the output ranged from 26 to 43% reduction.
40% of the output ranged from 44 to 77% reduction.
15% of the output ranged from 34 to 48% reduction.
Probably 80% of output 50% or less reduction.

The above material covering a range of .250 to .015 in thickness, about 20" wide maximum.

In judging the performance and practice of the past you must bear in mind requirements of the Trade.

Due to the fact that many of the cold strip mills also rolled their own hot strip, you will find that the increase in width of both hot and cold strip was parallel throughout the Industry. The width ranges being approximately as follows:

1893 - 7"; 1901 - 12"; 1905 - 16"; 1917 - 24"; 1925 - 36"; 1927 - 48"; by 1934 probably 72" wide. From 1893 to 1905 we have a jump in width in slightly over 100%, during a period of 12 years, that is, 7" to 16".

From 1905 to 1917, which included the War Period, we had a jump in widths of approximately 50%, that is, 16" to 24".

From 1917 to 1927, a period of 10 years, we again have a jump of 100%, that is, 24" to 48".

From 1925 to 1934, we will again have a jump of approximately 100%, 36" to 72".

You will note, therefore, that there has been a steady increase in width from 7" in 1893 to 72" in 1934.

In the decade between 1917 and 1927 an interesting phase took place in the Strip Industry. Backed-up Mills had been known and used for many years. With the building and installation of a large Backed-up Mill designed for cold rolling material up to 37" wide, installed at the Huntington Plant of the International Nickel Company, the interest in this type of equipment was revised. It was visited and admired by practically all of the Sheet and Strip Manufacturers in the Country and thereafter followed in quick succession, the Copper Mill at Rome; the installation at Cuyahoga; at Forged Steel Wheel Company; Weirton, etc., in the order named. While the author designed and built the Mill for Huntington, he cannot help but state that the inspiration came from the small Backed-up Mills of the American Tube & Stamping Company. You will see, therefore, that there has been nothing real sensational in the growth of the Industry as some individuals would have you believe, but a more or less gradual and logical increase according to the demands of the buying public and as the output could be absorbed.

The author stated previously that practically all of the elements were well recognized and understood prior to 1918. Our work from there on has been in the line of specialization and improvements in design and the general adoption of Electric Drives and Anti-friction Bearings. There has been a great deal of agitation within the last few years in regards to the Industry. One person claims that the supreme element is tension rolling; another claims Roller Bearing is the prime factor; another says Rising Temperature of the Roll Neck is the prime factor; another says the Diminutive Roll is the prime factor; another says Speed is the prime factor; another says Heavy Reduction is the prime factor, another says the Hard Roll is the prime factor; another says the Backed-up Mill is the prime factor. They remind me a good deal of the fable of the five blind men who went to inspect an Elephont. The one grabbed hold of the tail and said, the Elephant was very much like a rope; the other one felt the ear and said, it was very much like a palm leaf; the other felt the Elephant's side and said, it was very much like a wall; another felt the Elephant's leg and said, it was very much like a tree; the other felt the trunk and said, the Elephant was very much like a snake. The moral is, that they were all partly right, but mostly wrong. No one single factor has alone contributed to make the Industry what it is today.

The object of cold rolling is to produce a good surface combined with accurate gauge. Let us at this point stop and consider what elements effect the gauge of the finished strip? There are at least eight of these elements.

1. Roll Contour Variation.
2. Variation in gauge of initial hot strip.
3. Unequalled elasticity in rolling apparatus.
4. Variation in speed of rolling.
5. Accumulation of heat in apparatus and material.
6. Variation in tension during rolling.
7. Variation in lubrication of rolls and strip.
8. Wear on bearings and rolls.

Of these, the first and fifth are the most important and will be discussed later in detail.

In regard to variations in the hot strip, these can be, to a great extent, corrected during the cold rolling, providing they are within reasonable limits. The other elements are also within control today and have probably more to do with the human element operating the apparatus, than with the apparatus itself.

In regards to the wearing of bearings, this has been receiving a great deal of attention and to a considerable extent the bearing situation has been eased by the use of roller or anti-friction bearings. As far as the writer can recall, the terms—Ball Bearing, Roller Bearing and Anti-friction Bearing, have been synonymous. Lately opinions have been ventured that a roller bearing is only anti-friction when the rollers are spaced apart by means of a cage. This looks like an exceedingly fine discrimination, as bearings of both types have been manufactured, sold and used for many years. Excellent examples

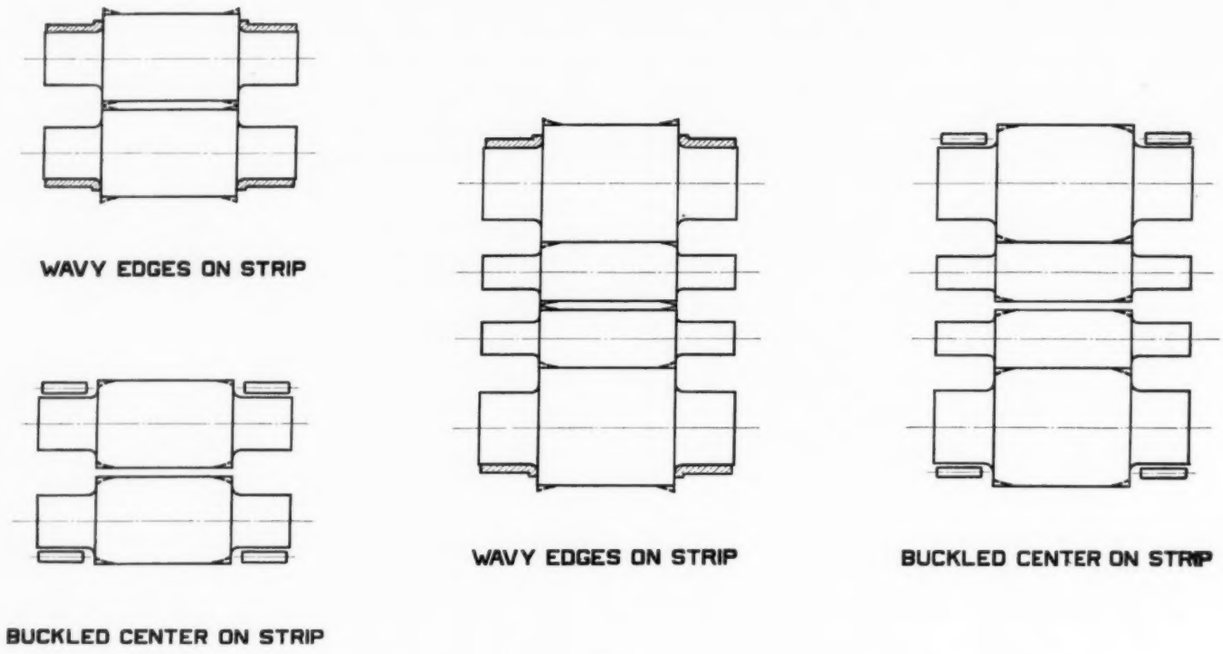


FIG. 7.

of commercial roller bearings without cages regularly manufactured, of the full roller type, are those made by Rollway Bearing Company, Tyson Bearing Company and the Bantam Ball Bearing Company. There probably are others, but believe that the ones mentioned are the most prominent producers.

The contour of the rolls are effected by a number of items as follows:

1. Deflection, which varies with the pressure on the screws and the width of material rolled and the material of which the rolls are made. In Four-High type of Mill, there may also be a side deflection in case the material is rolled under considerable tension.

2. Type of bearings used affecting contour.

On Figure 7 you will see in diagrammatic form the effects which various type of bearings tend to produce on rolls. Illustrated are two types of mills, one being the Two-High; the other the Four-High. The heavy lines indicate rolls as true cylinders; the dotted lines indicate the changes produced. These are shown exaggerated in order to be discerned by the eye. On the left, we have ordinary brass bearings, which on account of poor lubrication have a tendency to generate heat in the necks. If the neck temperatures become greater than the working temperature of the roll body, the ends of the body will be increased as shown, and if material was rolled the full length of the body, there would be a tendency to produce wavey edges.

On the right side is the effect produced by roller or anti-friction bearings. Due to the little heat generated, the neck of the roll is generally colder than the body. Here, we have a reversal of conditions, where a body heat tends to flow into the necks creating a lower temperature at end of the roll, resulting in a decrease in diameter. If material was rolled the full length of the body, strips with buckles in the center would result. These principles have been known throughout the Industry for many decades.

In the case of ordinary Bearings, the rolls were increased in diameter at the middle of the body, so as to compensate for the deflection of the roll and also for the increase in diameter at the ends, due to the heat generated in the necks.

With Roller Bearings and well designed Oil Bearings, the rolls shown on the right were either ground true cylinders, or only slightly increased in the center. The importance of this subject has been over-emphasized within recent years. Strip is never rolled of a width equalling the length of a roll body. Generally there is from 2" and up clearance between the edge of the strip and the edge of the body. The deformation in both cases **has to be corrected,** for obviously strip with a buckled edge is no more serious a defect than strip with a buckled center.

3. Perhaps the most important cause effecting roll contour is the heat developed during the rolling of the strip and the rate at which this heat is generated. The rate of input is directly effected by the draft, the speed and the degree of roll lubrication.

All of the electrical energy put into the apparatus is transformed into mechanical heat. A small portion of this heat goes into friction in the apparatus. This, in modern mills does not amount to more than probably 10 to 15%. The remainder of the energy is transferred into mechanical heat occasioned by the reduction of the strip between the rolls. There are 42½ B.T.Us. to each horsepower minute. Given the number of horsepowers for driving a mill and reels, it is very easy to calculate approximately the number of B.T.Us. input per minute to be taken care of. At this time, it might be well to describe the three different methods of rolling which have been in general use for many decades.

FIRST—DRY ROLLING—This consists in entering the strip between rolls where no lubrication or cooling is used. The principle use of Dry Rolling is to quickly close the open surface of steel strips.

SECOND—LUBRICATED ROLLING—This is used for effecting heavy reductions and conserving as much power as possible, by introducing lubricant either on the strips, or on the rolls; the function being to keep a film of oil between the strip and the rolls, greatly reducing what is known as skin friction. The value of a lubricant is shown in an article called, "Forces Acting on Cold Neck Bearings," by Professor W. Trinks, in the Transactions of American Society of Mechanical Engineers.

The value of a lubricant has been long known in the Industry and a study of these charts will show the advantages to be gained, not only in the savings of power, but also reducing the pressure on the bearings. Time is too short to introduce this factor into the discussion today in detail.

The two systems mentioned above depended entirely for a balance of temperature by radiations to the atmosphere plus the increase in temperature of the strip being rolled. The speeds of the mills under such conditions, could only be such as would maintain the heat balance. If heavy reductions were taken slower speed were necessary. If very light reductions were taken, higher speeds could be obtained. As explained before, the Mills were more or less of a jobbing nature and therefore speeds suitable for general conditions were determined upon and generally used.

THIRD—The third method of rolling was to lubricate and cool at the same time. The general practice, particularly in the Tandem Mills, was to introduce the lubricant onto the rolls and the strip and at the same time apply water for assisting in conveying away the mechanical heat. This cooling and lubricating method was well understood and used for many years. Prior to 1918 the author built several Mills where heavy reductions were made with speed as high as 430 feet per minute, the rolls and bearings being flooded with a combination of water and soluble oil. The mills, I believe, are operating today.

With the use of fluids for cooling, the amount of work performed on the mills, was increased with heavier drafts and greater speeds. As new installations were made, higher speeds and heavier mills were used. The amount of work accomplished being limited by the capacity of the neck bearings and the distortion of the center of the roll body. As about 25% to 40% of the power used for driving the Mills was friction on the roll necks, this heat had to be dissipated in addition to the heat generated by rolling the strip. With the development of sources for large roller bearings and their use on mills, this friction was reduced and therefore the amount of total heat to be dissipated was decreased by exactly the amount of friction eliminated. This meant that for any given installation the work on the mills could be increased by 25% or 40% by the use of roller bearings, either by increased speed or increased work per pass without changing the power input.

To do still more work required two things—greater unit pressure of the rolls on the strip to effect reduction, and more effective lubricating and cooling systems, so as to remove at a faster rate the heat generated by the work performed on the strip.

Greater unit pressure was obtained by the use of the Backed-up Mill where, great force can be exerted on a small roll without undue deflection. (Example—International Nickel Sheet Mill). Great unit pressures obtainable, the speed of doing the work then becomes a factor of heat control. Work in this instance, is the product of the force in pounds required to move the strip between the pressure rolls, a distance of one foot, and is measured in foot pounds.

The power to accomplish the result is the product of velocity and work divided by time.

Let us cite an example—

Two types of Mills rolling from .080 to .010, or a total of eight (8) elongations.

First Mill takes 3 passes—average speed 500 ft. per minute.

Second Mill takes 12 passes—average speed 1000 ft. per minute.

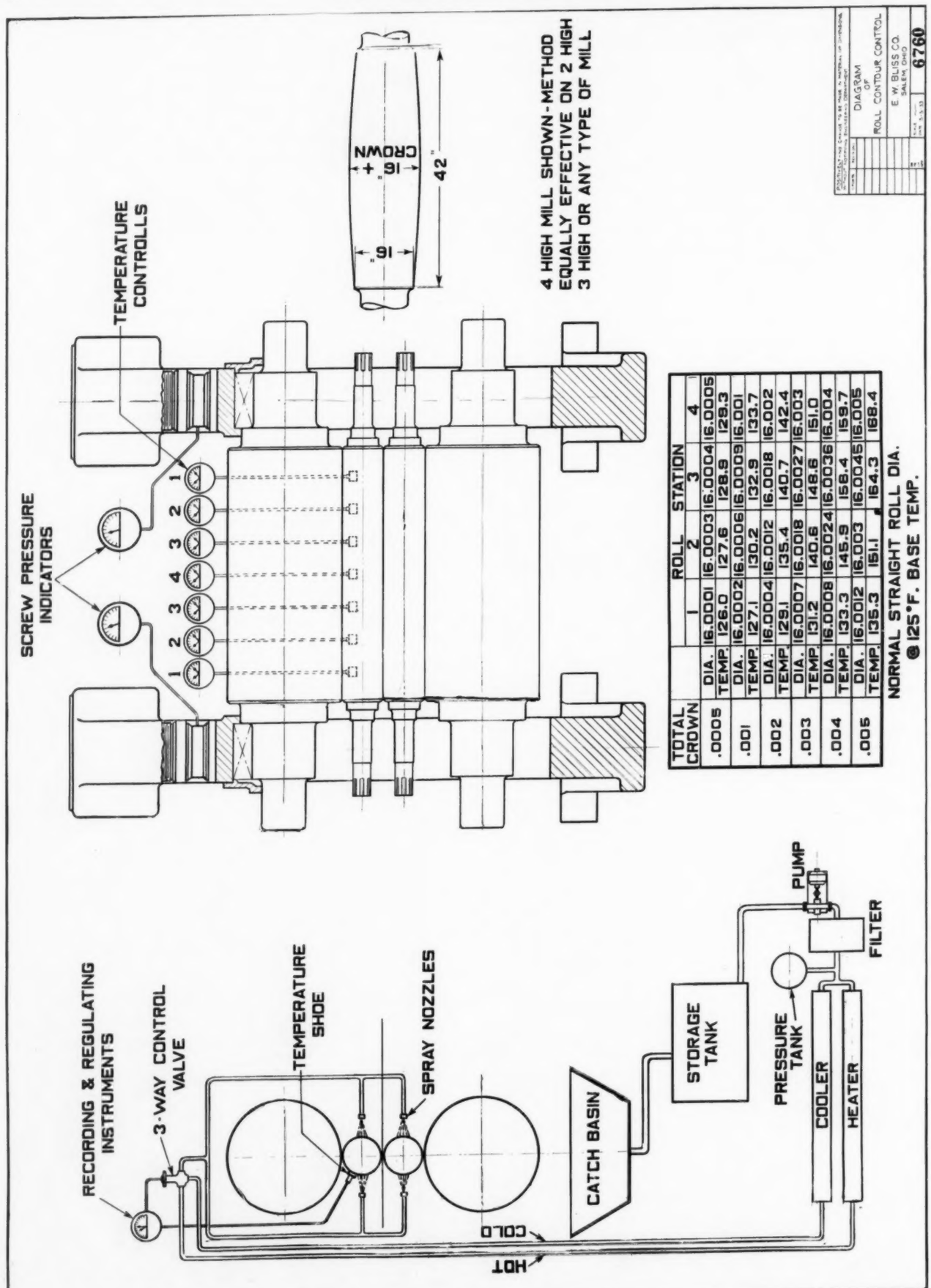
The total power required for rolling the strip will be approximately the same in both cases. But, the first mill running at half the speed will be performing twice the tonnage in an hour.

The first mill taking one quarter the number of passes will be doing four times the work of the second mill on each pass. To equal the first mill in tonnage, the second mill must average 2000 ft. per minute. When the first mill runs at 1000 ft. per minute the second mill for equal tonnage must run at 4000 ft. per minute.

A number of years ago, the problem was put up to the writer to produce wide strip to thin gauges as economically as possible. The problem, as you can see was one entirely of controlling temperatures and by so doing, keep the rolls at a uniform diameter, so as not to have excessive gauge variation of the strip. We made a study as to the temperature effect of various roll diameters, selecting rolls 5" and 16" in diameter. The radiating surfaces of these two rolls are in the ratio of 3-1/5 to 1. The mass, however, is in the ratio of approximately 10 to 1. In order to use heavy drafts, accomplishing the reduction in as quick a time as possible, we decided upon the larger roll, due to its increase in mass and greater lateral strength to overcome side deflection, due to the tension from the reels.

Another factor in determining the size of the roll was the increase in surface area which permitted us to apply more efficiently the cooling and lubricating medium. In discussing the matter with Mr. Walter Clark, of Bridgeport Brass Company, he stated that he had been studying the question for a long time and had evolved a process of automatically controlling the cooling fluids. He has applied for a number of patents covering these features in this country, as well as England, France and Germany. A number of these have already been granted and others, I believe, have been favorably acted upon.

Figure 8 shows in diagrammatic form our apparatus as applied to Mills. At the left, we see an end view of the apparatus; the center shows a front view of the Mill. The working rolls are divided into a number of horizontal divisions, each provided with a temperature shoe riding on the roll, connected with recording and regulating instruments. These instruments operate three-way control valves in such a manner as to introduce either a hot fluid or a cold fluid, or a mixture of the two to each roll section. The cooling and lubricating fluid is caught in a basin at the bottom of the Mill, where it is



TOTAL CROWN		ROLL STATION 1	2	3	4
.0005	DIA.	16.0001	16.0003	16.0004	16.0005
	TEMP.	126.0	127.6	128.9	129.3
.001	DIA.	16.0002	16.0006	16.0009	16.001
	TEMP.	127.1	130.2	132.9	133.7
.002	DIA.	16.0004	16.0012	16.0018	16.002
	TEMP.	129.1	135.4	140.7	142.4
.003	DIA.	16.0007	16.0018	16.0027	16.003
	TEMP.	131.2	140.6	148.6	151.0
.004	DIA.	16.0008	16.0024	16.0036	16.004
	TEMP.	133.3	145.9	158.4	159.7
.005	DIA.	16.0012	16.003	16.0045	16.005
	TEMP.	135.3	151.1	164.3	168.4

NORMAL STRAIGHT ROLL DIA.
@ 125°F. BASE TEMP.

FIG. 8.

drained into a storage tank, then pumped through filters and through heating and cooling units. Each section of the roll is approximately held at the temperature set on the regulating instrument. Let us assume for an illustration 125°. As the material enters the mill and by introducing heat tends to increase this temperature above 125°, the control valve automatically functions introducing colder fluid. If the rate still increases the valves keep on functioning introducing more and more cold fluid. After the strip leaves the rolls and the section tends to cool down below 125° the valve again automatically functions introducing more hot fluid. If all of the regulating instruments across the face of the roll were set at 125° obviously the roll would remain a straight cylinder. Due to deflection in the rolls, it is generally desirable to have the rolls crowned sufficiently to overcome this. The amount of crown will depend upon the width of the material rolled and the pressure used. It has been the practice in the past to grind the crown on the rolls. With this system, however, it is not necessary—as, by changing the setting of the regulating instruments any crown desired can be secured within a few minutes and be automatically maintained. The chart shows the temperature adjustments and the variation in roll diameters for the crown.

By this process, you will note that the roll contour is entirely independent of the influence of neck bearings, etc. as, each section will automatically select the temperature of the fluid required to maintain operating conditions. In case of Brass Bearings, the heat coming from the necks intending to swell the end sections of the roll would be counteracted by cooling fluid. In the case of roller bearings where the neck temperature is less than the body causing a tendency to decrease in diameter, the end sections would automatically be increased by hot fluids.

Another benefit and an important one, by the use of this system, was, stopping the spalling of hardened steel rolls, by maintaining them at a uniform temperature, regardless of operating conditions. While the base temperature indicated on the chart is 125° this can be changed higher, or lower, as desired.

The automatic roll temperature and contour control system just described is without doubt the finest cooling system yet devised. It is quite expensive, but most good things cost money.

Do not understand that it is absolutely essential to have automatic control. Strip can be rolled without this feature. Also, contour control is not essential. You can crown the rolls in the grinding machine and change them if the crown is not correct.

As far as fluids are concerned, you do not absolutely need two different temperatures. You can get along with only one. But, it is not so easy to keep the rolls in proper shape and at constant temperature.

Cooling can be accomplished by simply flooding the rolls with a great amount of water and the results obtained with heavy drafts at slow speeds are quite satisfactory.

When it comes to high speeds and heavy drafts, the results have not been satisfactory. The author recalls one installation made for the Acme Steel Company, where a Tandem Mill was installed and guaranteed to roll, with heavy drafts, at speeds up to 800 feet per minute. The rolls were deluged with water and carried away the heat, but the roll breakage was so great that the speed had to be reduced to 400 feet and less. The guarantee was never met.

The author lost that order because he refused to guarantee the performance, but advised them, he thought the conditions possible. He still thinks so, but they need a real temperature control system, one that will not subject the rolls, 400 times a minute, to extreme temperature fluctuations of approximately 100°. Don't take my word for it, ask your hardened steel roll maker.

Only the other day, I was asked to guarantee 50% reduction at 1,000 feet per minute. I told them in my judgment it was possible, but would not guarantee it. Again, we lost the order and I am wondering if the other fellow again gave a guarantee. The request for such guarantees are not fair because under present conditions there is not enough profit in the order to cover the risk, and when you put enough into the price to cover equipment which will make my judgment better than a guarantee, you lose the order.

We believe and have proven that the most successful performance is possible when maintaining the rolls at a constant base temperature and that base temperature should not be less than 100° and preferably higher.

Controlling temperature, whether automatic or by hand, is so vital a part of the present day high production mill, that any one who buys such apparatus on the pound price basis, or any basis, other than merit, is making a mistake.

I would like to point out to you the two dials at the top center of the front view called, "Screw Pressure Indicators". Under each screw is located pressure devices, which indicate pounds on the dials. In rolling thin material, the rolls are forced together under considerable pressure; the opening for the strip being obtained by the extension of the housings of the mill. Obviously, with the rolls pressed together as Indicator reading, "Fractions of an Inch", would be of no value, especially when we are dealing with variations of one-quarter thousandths of an inch. Screw pressure is, however, a true indication and if the pressure on the two screws is identical, the work on both sides of the mill will be the same. The setting of rolls by pressure has proven to be a very practical and useful method.

By the use of large diameter rolls, capable of being driven by powerful motors combined with an efficient cooling and lubricating system, together with other refinements, we have found it possible to roll steel approximately 36" wide about .080" thick to 32 gauge, or .010" thick in from 3 to 5 passes at speeds of 400 feet per minute. The indications are, that we will be able to conduct heat still more efficiently and with the same heavy reductions probably double or triple our speeds. The problem of high production cold rolling today is largely one of heat. As far as the work rolls are concerned, we have the choice of hardened steel rolls, or hard cast rolls.

With reference to the bearings, you have the choice of a number of different types and makes, all of which have approximately the same efficiency. On the other hand, well designed lubricated bear-

ings can be used; the efficiency of which would not be greatly in excess of the roller type.

When it comes to cooling and lubricating fluids, while you have the choice of several mediums, you cannot very well do without one of them. Take any high production mill, rolling wide widths and thin gauges at high speeds, and cut off the cooling fluids, you will find that production stops immediately, or else, the operating temperature will increase to such a high level as to make gauge variations and buckled strips a most troublesome problem.

Cold Rolling Methods for producing material are quite flexible. You have the choice of Single Mills, Reversing Mills and Tandem Mills. You have the choice of small rolls with the power principally applied by tension, or large rolls with most of the power direct connected. You also have the choice of operating mills where the heat balance is maintained below 200°, using considerable volume of cooling fluids or of raising the heat balance above 200° using less cooling fluids and depending upon radiation to the atmosphere.

All of the various systems are in practical use today, producing the same class of products, all on a commercial basis. A good example is the present strip tin plate product. This product is made by three entirely different processes. They are:

FIRST—The single Stand Mill Tension Processes, where the strip is pulled through dies of a diameter not exceeding 6". The main force being exerted by the pull of the reels using about eleven to thirteen comparatively light passes.

SECOND—The Single Stand Mill Process (old type) using large diameter rolls and very heavy drafts. The main force is exerted through the rolls using about three to five heavy passes.

THIRD—The Continuous Mill Process consisting of three to five stands in Tandem. The main force being exerted through the rolls, using one pass.

Each of these processes is at the present time producing 1½ to 2 tons per hour per roll stand. The tension process however, has about reached its limitations, due to being confined to rolls less than 6" in diameter. The temperature difficulties with rolls of this size increase rapidly as speeds and drafts increase.

We may therefore, expect that in the future, the old type large diameter roll mills will receive their proper recognition and be generally adopted either in the Single Stand or Multiple Stand Continuous Type; the large rolls being ideal for heavy drafts and rapid heat transfer. The old type mill, in our judgment will soon be producing double and triple the tonnage possible on a tension mill, at less cost per ton of product.

The first mentioned process was put into practice by the Cold Metal Process Company of Youngstown, Ohio, wherein the strip pulled by the reels through rolling dies 6" or less in diameter, has been in use at the Weirton Steel Company, and a recent installation started at Follansbee Bros.

The second type being the Single Stand Mill, using large diameter rolls and heavy drafts and Modern Cooling System was developed by the E. W. Bliss Company, and was first used by the American Sheet & Tin Plate Company. Another concern, namely Jones & Laughlin Steel Corporation, has recently entered the field, also adopting this type of mill which will be built for them by the United Engineering & Foundry Company. What kind of a temperature control system United will develop, will be awaited with considerable interest.

The third process, that is, Continuous Mill, was first used for Tin Plate at the Wheeling Steel Corporation, equipment having been designed and built by Mesta Machine Company. I think this Mill runs with rolls at a very high temperature, depending largely on radiations for cooling, using moderate speeds. I have not seen the mill operate and speak only from hearsay. You will note that Mesta Machine Company, Cold Metal Process Company and E. W. Bliss Company all have Mills in operation on this product. The United Engineering & Foundry Company is venturing into this field. With four such prominent concerns working on the same problem, the Industry may expect considerable progress within the next few years. Due to the limitations of the small work roll in regard to drafts and heat dissipation, we believe that rolls 14" to 18" in diameter will be found so superior in tonnage output that they soon will be in general use. While strips of tin plate gauges are being produced today at rates of 1½ to 2 tons per hour per Stand, the author thinks that this tonnage will very soon be doubled and within the course of the next two years, tripled or quadrupled.

You will note that the progress of the Cold Rolling Industry has been one of almost continuous advancement and judging from the past we may expect considerably further developments.

In conclusion, allow me to say that Salem is not as large an Industrial Center as Pittsburgh, nevertheless, its contributions to the Rolling Industry, in the last decade, have been considerable.

The following are a few:

1. Demonstrating to the Industry the modern possibilities of the forgotten Backed-up Mill. (International Nickel, Huntington).
2. Rolling strip under tension between stands of Continuous Mills. (Clark Patents—many installations).
3. Introduction of Method of making High Grade Sheets, by cold Rolling. (Huntington and McKeesport).
4. Building of the first Continuous Backed-up Mill, equipped with roller bearings for rolling sheet strip wider than 24" (Cuyahoga).
5. Adaption of roller bearings to work rolls of Four-High Mills, holding the rolls in accurate alignment and making this type of mill a success. (McKeesport).
6. Introduction of modern cooling systems for Mills.
7. Introduction of Automatic Temperature Control on Rolls.
8. Introduction of Contour Regulations.
9. Introduction of roll adjustment by pressure indicating device.
10. Introduction of Laminated Rolled or Forged Steel Housings.
11. We hope being instrumental in securing better roller bearings.

New Developments In A. C. and D. C. Welding

By W. C. PEARSON
Engineer, Westinghouse Electric & Manufacturing Co., Chicago, Ill.

Presented before the Chicago District Section of the A. I. & S. E. E., May, 1933.

In view of the limited time available for presentation at a symposium of this kind, it will not be possible to deal with the detailed history of the development of welding devices.

It will therefore be my intention merely to present two recent Westinghouse developments, namely, the "flexarc" d.c. welder and the new a.c. welding transformer.

The development of the constant current welding machine was undertaken by several manufacturers in an endeavor to eliminate certain undesirable operating features of constant voltage machines, such as the necessarily very low efficiency of operation.

Our new constant current machine has many operating characteristics in common with machines of other manufacturers.

We believe it is safe to say that the majority of single operator machines in service today are those which have a series field winding connected to buck the excitation produced by a separately excited field. This type of generator has a volt ampere characteristic approximately as illustrated by Fig. 1. However, a machine having these volt ampere characteristics does not necessarily possess all of the features desirable for welding. Such volt ampere characteristic curves are obtained by connecting a fixed resistance in the external circuit of the generator and then reading the voltage drop across the resistance and the current flowing through the resistance under stable conditions when the current and voltage have settled down to a fixed value. Then the resistance is changed and another reading is obtained and this cycle is repeated until a family of curves is obtained. Under welding conditions, however, the resistance of the welding circuit is continuously varying over relatively wide limits at very short intervals of time. These variations are produced by a number of causes. First, the work being welded and the electrode wire being melted are in a violent stage of agitation which inherently causes the effective distance from one to the other to vary exceedingly rapidly even though the operator may maintain a very steady rate of feeding the electrode toward the work. Furthermore, globules of metal are continually leaving the end of the electrode and traveling through the arc stream to the work being welded. These globules of metal vary in size so that again the resistance of the arc stream is caused to change rapidly. Furthermore, the operator cannot possibly feed his electrode toward the work at a uniform rate and therefore other variables are produced in the welding circuit. As a result therefore the generator should be capable of varying its voltage almost instantly to just the right value to keep the current through the arc at the value required by the welding operation in hand. The necessity for rapid generator voltage variation is almost obvious if one stops to consider that when the machine is operating under open circuit and the electrode is touched to the work it is necessary for the generator voltage to change from open circuit voltage to a much lower voltage instantly if the current delivered through the circuit is not to be a very high order represented by the current which say 60 volts can force through a very low resistance. Oscillographic tests on most generators in welding service will show that the momentary current flowing may be from 5 to 8 times the normal welding current. To help reduce these variables all such machines have reactors of varying values in the circuit to choke the rush of current which would otherwise pass through the welding circuit. There is, however, naturally a limit on the amount of inductance which can be provided in a reactor to make up for deficiencies of speed of voltage change in the generator itself. If the reactor is of too large a value the welding circuit tends to become sluggish and gives unstable characteristics. Furthermore, a rela-

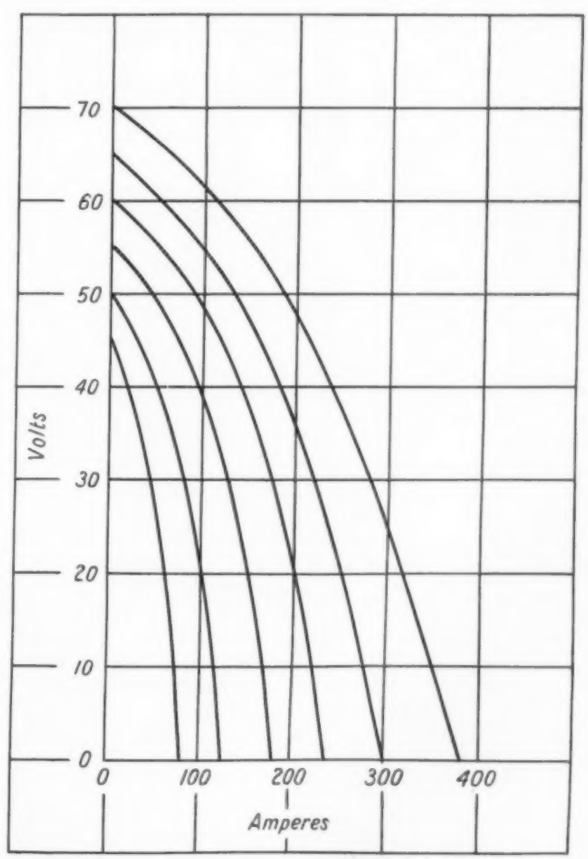


FIG. 1.

tively large reactor adds appreciably to the cost of the equipment due to the volume of copper and iron required in its construction and the labor of assembly. For this reason about two years ago our engineers endeavored to determine a new method of speeding up the field action of our single operator generators by means of a new scheme which has resulted in the production of our new single operator arc welding generators.

These generators are provided with a flexactor which is quite distinctly different from the old stabilizer or reactor which has been used in the past with commercial single operator generators. This machine in fact is a transformer having two distinct windings closely coupled. The primary of this transformer comprises a relatively few number of turns of large strap copper sufficient to handle the welding current output of the generator. The secondary winding of this transformer comprises a large number of turns of copper approximately the same size as the separately excited field winding of the generator. This secondary winding is connected in series with the field of the generator. As a result, when the current from the generator armature flows through the primary of the reactor it induces a voltage in the secondary which in turn is immediately impressed upon the field circuit of the generator in such a way that the voltage response of the generator is so instantaneous that the current delivered by the generator is at all times practically that for which the generator is set to deliver under normal welding conditions of 20 volts across the arc. As a matter of fact, the various portions of the circuit can be calculated and designed so that no rush of current is experienced when the electrode is touched to the work thereby preventing the tendency for the electrode to stick to the work which is always noticed especially by operators who are learning to weld.

The general appearance of one of these single operator machines is shown by Figure 2 which illustrates the a.c.-d.c., 200 ampere stationary equipment. The small unit extending at the right of the set is the exciter for supplying the separate source of excitation for the generator field. By adding parts, this unit can be converted for portable service.

All of these machines are provided with very rigid shafts 3" or more in diameter, depending upon the rating of the set, but in each case they are very rigid relative to the size of the generator armature and the motor rotor. Our reason for going to such a heavy shaft construction is that considerable trouble has been experienced with some sets on the market due to the shaft springing and allowing the rotating element to wreck itself by springing against the stationary part of the machine.

Our company has felt for a number of years that a.c. welding had definite possibilities, particularly in the field of thin gauge metals. A.C. was also attractive from the standpoint of compactness, availability, and freedom from rotating parts.

However, the early experiments with a.c. welders disclosed many objectionable features such as the following:

High open circuit voltages were necessary to establish and maintain the arc, because of the fact that an alternating current goes through zero during every cycle thus having a tendency to snuff out.

In order to counteract this tendency of the arc to break, a reactance was added to throw the current and voltage out of phase so they would not pass through zero at the same time, i.e. so there would always be voltage to maintain current at the time of current reversal.

These high a.c. peak voltages (in the nature of 200 volts) presented a considerable hazard to the operator.

Also, on account of the high striking voltage there was a distinct tendency to burn through thin materials. Further, on account of the inherent high reactance of the unit, a very low operating power factor was obtained (in the nature of 25-35%).

The requiring, furthermore, of a single phase source, made the unit a very undesirable load.

The new welding transformer which has been developed by our company overcomes all of these major objections to the early designs.

The welding transformer proper, is perfectly standard in all of its design characteristics and features and is identical with standard commercial distribution transformers in construction. It is provided with a primary which can be connected in parallel or series for 220 volts or 440 volts and is provided with a secondary which delivers a practically constant potential of 73 volts which is used on the welding system. In this respect from the apparatus standpoint the equipment is very similar to d.c. multiple operator systems where the d.c. generator operates at a constant potential of approximately 60 volts and the current is supplied to the welding circuit through a series of control resistors for stabilizing the arc and for permitting the operator to adjust the current delivered at the arc to the value required for the work at hand.

The most interesting feature and novel portion of this a.c. welding equipment is that of the oscillator circuit, which super-imposes high-frequency oscillations on the welding circuit. The general basic idea of such use of an oscillating circuit is not new since it was (according to records) proposed in 1879. However, we do not know of any previous commercial use of the idea in this country.

The scheme of connections for the welding circuits, oscillator circuits, and power input circuit is as follows: The oscillator circuit comprises a small standard transformer, a condenser across the high side or secondary, two spark gaps, and an air core choke coil. The transformer is connected on the primary side to the power input for the welder, and supplies through its secondary the necessary voltage to charge the condenser and jump the spark gaps. This produces oscillation between the condenser and choke coil of a frequency determined by the relation between the capacity of the condenser and the inductance of the choke coil. This particular equipment is designed so that the frequency is below the radio broadcast band to prevent interference and as an additional assurance a condenser is connected across the power input terminals of the equipment. At the same time, the frequency selected is sufficiently high to preclude the possibility of any injurious physiological effects upon the person using the apparatus.

To perform the desired functions it is necessary to have the oscillator circuit discharge between the welding electrode and the work but it is also neces-

sary to prevent the welding circuit from supplying any energy to the oscillator, therefore two small condensers are placed in the circuit between the oscillator and the welding electrodes. These condensers block the low frequency welding current but allow free passage of the high frequency discharge through the welding electrode and the work. Similarly a condenser is connected across the input terminals to prevent the oscillator from feeding into the power circuit which might cause radio interference with sets in the immediate territory.

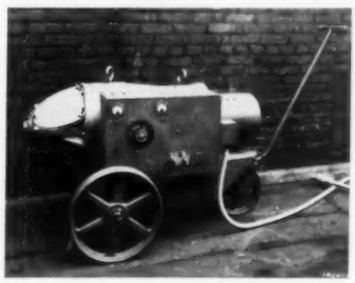


FIG. 2.

The voltage developed by the oscillator circuit is sufficiently high so that the discharge will actually start just before the electrode contacts the work. As soon as the discharge starts the ionized gases between the electrode and work produce a low resistance path for the welding current so that the arc starts very easily, in fact just as easily as a d.c. arc. Some operators actually prefer this circuit to some d.c. circuits because the arc can be started without actually making contact, thereby eliminating the sticking (freezing) of the electrode to the work.

So long as the welding arc length is maintained, the oscillator continues to discharge between the electrode and the work and eliminates the tendency of the arc to snuff out each time the welding current passes through zero. In previous designs of welding transformers these characteristics were approached by designing for an open-circuit secondary voltage of about 125 volts (compared with 73 volts for the improved transformer) and for high leakage reactance to throw the voltage and current out of phase so that when the current passed through zero the maximum voltage would be available to prevent the current from being interrupted. To obtain different current values regulating resistors are used.

The current regulating resistors are connected to five switches and are designed so that currents of 4, 8, 16, 32, 64 amperes, and any combination from 4 to 125 amperes in steps of 4 amperes may be obtained. It is therefore possible to adjust the current value to within 2 amperes of any desired value. The equipment is especially desirable for welding sheet steel and aluminum in the thinner gauges below No. 16 in which field the a.c. arc has not been particularly satisfactory up to the present time.

With this new design a power factor of 90% is obtained with a load as small as 40 amperes and increases with increase in load reaching 98% at full load. This is a distinct advance from earlier designs which operated at 25 to 35% power factor.

The welding operator will not experience any bothersome shock from the welding circuit which was one of the major objections to older designs nor from the oscillator circuit because of the very high frequency of the oscillator circuit producing the well-known "skin-effect," and because of the low capacity of the oscillator circuit.

The mechanical construction of the new welder is both simple and sturdy. The welding transformer, oscillator and current regulating resistors are assembled in an arc welded sheet metal case, which is provided with wheels and a suitable handle for conveniently moving the unit.

The quality of the welds made with this improved a.c. welder is in every respect equal to d.c. welds. Many tests of such welds have been made and in one series of ten tests using hot rolled steel plate the average tensile strength was 52,000 lbs. per square inch.

Because of the low no-load losses, low investment charges and low maintenance (no rotating parts) the a.c. equipment is very economical to operate especially when welding materials of 16 gauge and less. It is probably destined for extensive use particularly in fields where the d.c. arc has not made much headway.

New Uses For Steel

By CHARLES F. ABBOTT
Executive Director, American Institute of Steel Construction, Inc.

In the field of steel construction we have been conducting research, planning new inventions and discovering new methods which are calculated to effect a change in the years ahead. It is our belief that these inventions and improvements will prove profitable to us and to our customers. It is my conviction that the future success of our industry depends to a large extent upon these improvements.

Through greater knowledge of the nature of our raw materials and by means of improved knowledge of the methods of utilizing them we can make structural steel render a greater service than ever before. We can remake or rebuild our entire world.

The five day week is opening up new possibilities for amusements. The elimination of city slums is a problem that is daily assuming greater political significance. Construction will be proportionately affected. We will encourage municipal and national parks and the completion of swimming pools, outdoor gymnasiums and country hotels.

Additional leisure will promote the building of many structures for indoor recreation and amusement. The theatres and movies will flourish, great arenas for football, baseball, tennis, skating, and the like will be built to permit outdoor sports for winter and at night.

The abolition of the Eighteenth Amendment, without the return of the saloon, but with more general leisure, may well bring about the European

method of drinking, with a demand for beer gardens, dance pavilions and music halls.

We shall construct many straight highways for travel and traffic and winding roads of scenic beauty for pleasure driving.

The modern home market affords an interesting study. Applied research would reveal a much greater opportunity than is now generally recognized.

For forty years we have been dreaming of building residences of steel. During the past few years nearly sixty different systems of such construction have been analyzed. These studies have developed much information as to the most economical method of home construction.

The use of Junior Beams and Channels, produced by the Jones & Laughlin Steel Corporation, and the light weight joist sections of Bethlehem are increasing as more steel for floors, roofs, columns and stairs is being used in the present type of residential construction.

The American Institute of Steel Construction sponsored a small house forum that aided in the crystallization of thought on this problem. This year the United States Steel Corporation will issue a handbook on house construction which promises to stimulate the use of steel in this important field.

A man goes to work in a steel train, completely firesafe. He works all day in a fireproof office or factory and seeks amusement in a fireproof theatre. But usually he has left his wife and children at home in a fire-trap house. There is no reason why he should risk the lives of his loved ones, when a fire-safe residence of steel combined with other materials is not only practical and available to him, but can be obtained at no increase in cost. Steel for residences will undoubtedly become an important market for the steel industry in the years to come.

Consider for a moment the number of cheaply constructed frame structures that were erected during the past ten years and their high rate of depreciation. Consider the number of old-fashioned houses without modern equipment, out-dated in style and appearance. They have all been rendered obsolete and must be modernized or demolished to make way for the new.

Progress is demanding the erection of modern fireproof apartments in restricted sections adjacent to our commercial districts. We cannot retard economic progress any more than we can control the ebb and flow of the tides.

Vehicular tunnels, great new bridges and motor viaducts are all indicative of a vast development in the movement of population that is now under way.

Our cities and towns must provide accommodations that will call for modern homes, apartment houses and commercial facilities, and this demands intelligent, progressive planning.

The development of air-conditioning is bringing into being a new industry of great possibilities. It will not be long before we shall be able to inhabit homes, offices and hotels with rooms of even temperature throughout the year and with better and more healthy ventilation.

The largest air-conditioning system in the world, involving more than a million dollars, was installed in the broadcasting studios and the lower floors of the new 69-story RCA Building in Rockefeller Center, New York. It will maintain an average temperature of 70 degrees Fahrenheit in winter and a maximum of 85 degrees Fahrenheit in summer. Humidity is varied between 40% in winter and 50% in summer. Carrier Engineering Corporation had the contract. Maxim-Campbell silencers and air filters are installed in offices in the remainder of the building.

Engineers have gained valuable experience in this field. It is much cheaper to install air-conditioning than ever before. We are demonstrating that residential units are quite economical and can be sold to home owners in the relatively low income brackets.

On the Pacific Coast particularly engineers have already started to use H-columns for piling. During the past year some interesting tests have been made and considerable technical data has been assembled. The industry will soon be prepared to issue to the engineering profession the essential tables to enable them to design H-column footings for buildings and bridges. That will make for great savings and result in greater security for future structures. The day will come when steel will be the foundation, superstructure and roadway of bridges and buildings.

A new system of fireproofing the steel used in our buildings will greatly reduce the cost of structures and this means lower rentals and lower service charges for the public. As we reduce our costs we automatically extend our markets.

Three years ago our Institute began a study of steel floor construction. A design of steel plates welded to I-beams was proposed. Before the necessary engineering data was even completed some 50,000 tons of plates had been used for garages, warehouses and office buildings. Tests have been made for strength, fireproofing and sound-conductivity, under the auspices of the U. S. Bureau of Standards, and they have exceeded all expectations.

The steel floor today is an established reality. Its widespread use would be an incident to business recovery. So promising is this technical improvement to the building industry that a number of patented types of steel floors are now being promoted.

The Carnegie Steel Company is offering the T-Tri-Lock floor. Its use is adaptable to bridge floors and approaches which are subjected to heavy usage. Engineers of the Belmont Iron Works of Philadelphia have designed a floor of interlocking channels. It has been successfully used in the rebuilding of a number of bridges necessary to withstand an increased traffic load. It has been incorporated in pier floors and warehouse storage sheds.

The H. H. Robertson Company of Pittsburgh is putting on the market a cellular steel floor, which, it is claimed, is ideal for buildings for human occupancy.

It is possible that there will be others on the market. Sufficient has already been developed to demonstrate the great improvement in floor construction that is now possible. They will permit of unit construction in the shop and rapid assembly in the field. The lighter construction will represent a considerable saving both in the dead weight of the completed building and in its ultimate cost.

Buildings with steel outer walls displacing the

heavy and costly masonry have been perfected. This new type of construction will add further cost reductions and when used for apartment houses the public should be able to obtain reduced rentals.

The development of steel floors for buildings and residences represents a new market that could call for more than 5,000,000 tons of steel. Better floors at lower costs would add greatly to superior and more economical structures.

Steel highway roadguards have been perfected and they are the only type that will keep automobiles and trucks from going off the road. When the public become acquainted with these life-saving inventions they will undoubtedly be installed to guard the dangerous places on all of our highways.

The estimated potential market for the new uses of steel as so far developed and found to be practical would undoubtedly exceed 20,000,000 tons if these new markets were fully developed.

This represents a volume five times the present combined production of the steel construction industry.

We must not forget, however, that research, new uses, and new markets will fail completely unless the public are first acquainted with and educated to all of the advantages. Their acceptance must first be obtained before a demand can exist. Orders never happen, they must be stimulated by conviction, and this calls for intelligent advertising, promotion and aggressive salesmanship.

High Manganese Steel Welding

By E. A. HURME
Clark Controller Co., Cleveland, Ohio

EDITOR'S NOTE:—Historical: "Early in the history of the use of manganese in steel it was observed that increasing the manganese content above .60 to .80% caused the steel to become proportionally harder and stronger until with a content of about 3.00% the steel was so brittle that it was thought metal containing a greater proportion of manganese would be useless. That this idea was totally erroneous, was first shown by Robert A. Hadfield in a paper on manganese steel read before the British Iron and Steel Institute in 1888. He found that while steel containing from 3 to 7% manganese was 'practically as brittle as glass,' steel containing from 7 to 20% manganese could, by proper treatment, be made very tough and strong. Besides, these alloys exhibited peculiarly distinctive properties. Hadfield's work showed that, with a carbon content of .80 to 1.30%, a manganese content of 10.00 to 15% gave steel in which the beneficial effects of the manganese were realized to the fullest extent."

In the commercial manufacture of manganese steel, the producer is forced by economic reasons to use as an alloying agent a ferro-manganese containing a rather high carbon content. This alloy agent generally contains 78 to 82% manganese and 5 to 8% carbon. At any rate the manganese to carbon ratio is more or less fixed at 10 or 11 to 1. As the manganese content of the final alloy increases, the carbon content likewise increases so that the upper limit of manganese which may be used with proper physical qualities is dependent upon the carbon content. It has generally been found unsatisfactory to exceed 1.40 carbon as the toughness of the metal rapidly decreases beyond this point. 1.40 carbon corresponds to about 15% manganese.

High manganese steel, because of its toughness and strength, and its characteristic property of hardening on the surface under pressure and pounding, is unexcelled for applications where abrasion, combined with impact or blows, must be endured.

Early attempts of manganese steel welding were far from dependable and while in some cases welds would last for years, in other instances such repairs actually lasted only a few months and sometimes only a few days.

These failures were usually due to lack of proper understanding of the weld and the parent metal characteristics and more especially to the fact that correctly designed welding rods were not available.

Today manganese steel castings and forgings such as cast screen segments, sheaves, sprockets, pump shells, runners and cutters, shovel teeth, bucket lips, crusher plates, mantels and all other 11% to 14% manganese steel castings can be successfully and satisfactorily repaired with electric arc welding, using suitable high manganese steel welding electrodes.

To obtain maximum strength, ductility and toughness, manganese steels are usually made to the following analysis:

Carbon	1.00	—	1.40
Manganese	11.00	—	14.00
Silicon	0.30	—	0.80
Phosphorus	0.06	—	0.10

Manganese steel has properties exactly opposite to a high carbon steel. If it is allowed to cool slowly from a red heat, it becomes weak and brittle while if it is water quenched, it is extremely tough and malleable. Properly heat treated manganese steel casting is generally cast first in a sand mold, cooled and then reheated uniformly to a temperature of 1750 degrees F. to 1850 degrees F. from which it is rapidly quenched in water. The difference in physical properties resulting from slow cooling and proper quenching from 1850 degrees F. is shown by the following table:

TABLE I

Physical Properties	Slow Cooled	Water Quenched From 1850 Deg. F.
Ultimate strength lbs./sq. in.	85,000-100,000	140,000-150,000
% Elongation in 8"	2-6	45-50
% Reduction in area	8	30-40

High manganese steel develops its excellent wearing and abrasive resisting qualities from cold working of the metal. In its original heat treated condition the metal has a scleroscope hardness of only 25 to 28 (174 to 187 Brinell). In this condition the metal may be filed and it dents more easily than low carbon steel. When the casting is hammered a few

times, the surface hardness quickly jumps to 70 to 74 scleroscope (485 to 514 Brinell). On the first blow the metal flows easily or spreads and increases only slightly in hardness. Succeeding blows produce less and less flowing action and increased hardness. Only the surface or the metal subjected to the actual rolling or working action is hardened. The body of metal below this hardened surface film remains soft and malleable. It is this characteristic of surface hardening, in combination with excellent physical properties, which makes manganese steel the universal choice for many applications where impact and abrasive wear are encountered. As the hardened surface film is worn away, a new one is developed by further cold working.

In order for manganese steel to resist abrasion there must be sufficient pressure or impact to cold work the metal and develop its hardness. At crossings, frogs and turnouts on both electric and steam railroads manganese steel castings have found almost universal use. In such applications there is the necessary impact as well as rolling abrasion to cold work the metal and develop its hardness. In a jaw crusher, for instance, where the steel is subjected both to heavy pressure and to severe abrasion, manganese steel will outlast from 5 to 10 times metals whose initial hardness is much greater. On the other hand, where the metal is not subjected to heavy pressure with its cold working, high manganese steel does not develop the same resistance to wear and may show more rapid wear. For example, under a sand blast where pressure is almost entirely absent it has been found that high manganese steel wears as fast as plain .25 carbon steel or cast steel and much faster than chilled iron.

High manganese steel shovel teeth will often last several months handling blasted rock of the hardest kind and wear out in ten days or two weeks digging into a bank of glacial clay or shale containing a large amount of quartz or other hard mineral in small particles. In the absence of the hardening effect of blows or pressure that dent and deform the steel, high manganese steel's resistance to wear is comparatively low.

Wear on a cast manganese frog or crossing is usually confined to a small part of the total surface area and the volume of metal worn away is relatively small. On the other hand, investment in the casting is great so it is highly economical to build up the worn areas by arc welding. This class of work is generally called resurfacing, and the results are highly satisfactory if a few well established rules are observed.

In the process of arc welding manganese steel, it is necessary to consider the composition of the deposited metal and the thermal treatment which the deposited weld metal receives just as they were considered in the making of the original casting. In addition, there is one other factor to be considered; namely, the effect which the welding arc heat has on the casting.

Straight manganese steel rods, conforming in composition closely to the manganese steel castings, have been used quite extensively for several years. When an arc is drawn and the weld metal is deposited on cold parent metal, there is almost instant quenching of the deposited weld metal from the molten temperature, due to the relatively massive size of the casting and the small volume of molten weld metal. For this reason quenching takes place more or less automatically and the heat treatment, which the weld receives, is exactly as it should be to produce toughness.

In Table I, is shown the physical results for slowly and rapidly cooled straight manganese steels. Any departure from a condition which gives rapid quenching necessarily means that the physical qualities of the weld will more closely approach the column of figures shown at the left. For this reason, the welding operator should use a rather low current, small size rods and weld short, narrow beads without excessive puddling or weaving in order to maintain the high quenching rate and to obtain the best quality of weld. If considerable welding is required in a small area or if the casting is small, it becomes more difficult to keep the work cool. The general practice has been to water quench each short bead immediately after completion of the weld. This practice, however, has not been entirely satisfactory because manganese steel in cooling down from a red heat undergoes a relatively high contraction and when water is suddenly applied to it, the weld, which is hotter than the casting to which it is united, develops fine hair line cracks. On the other hand, if the operator keeps the work cool by using a smaller electrode, lower amperage and by taking considerable time between beads to allow the work to air cool more normally the job progresses too slowly.

Manganese steel welding rods of more recent developments contain about 3.5 per cent nickel. This addition of nickel has the remarkable effect of retaining the maximum toughness of the weld metal even though the cooling rate may be greatly retarded. Water quenching becomes unnecessary in order to prevent embrittlement and cracking is largely overcome. These nickel manganese rods are generally air-toughening over a broad operating range whereas the straight manganese rods are air-toughening only under limited operating conditions. In using these nickel manganese rods, especially if they are of properly coated types, operator may advance the work more rapidly with the assurance that the weld metal will be tough and resistant to impact abrasion.

The beneficial effect of nickel in the manganese welding rod is in the improved nature of the weld junction.

This important improvement in the quality of the junction may be described in terms of microconstituents as follows:

Manganese steel heated to about 1850 degrees F. or above is in the form of austenite, and carbides of iron and manganese are in solution. If cooled suddenly, by water quenching these carbides are retained in solution and the metal is strong and ductile. If the metal is allowed to cool slowly from above 1850 degrees F. the carbides are given time to separate out and form at the grain boundaries. This structure is relatively low in strength and particularly low in ductility. The embrittling effect of this carbide separation is, of course, most pronounced at the weld junction. The addition of 3.5 per cent nickel causes the carbides to remain in solution even though the cooling rate may be greatly retarded. The net result is that the weld junction is stronger and more ductile.

In the application of manganese steel welding rods (with or without nickel) an additional factor arises of great importance. When a bead is deposited upon a casting, the metal contracts and considerable stresses are set up. These stresses multiply as additional beads are added and will lead to shrinkage cracks in the welded pad. As already mentioned in addition to contracting more than ordinary steel, manganese steel has the characteristics of being more sensitive to quenching from a red heat. For that reason water quenching is not recommended with some of the new nickel manganese welding rods. This accumulative stress condition is avoided by peening each short bead after it is deposited. The affect of peening is to spread the metal and mechanically relieve strains. In order for peening to accomplish the desired purpose the entire weld should be thoroughly worked from end to end with a heavy (3 to 4 lb.) hammer. **The importance of satisfactory peening cannot be over emphasized because it is the key to successful high manganese welding.** In addition to stress relieving, peening materially aids the operator in properly shaping the weld.

Figure 1 600 Magnifications:
Junction between straight manganese steel weld metal and low carbon steel plate. The zone just above the junction is one from which carbon has diffused into the plate. The removal of carbon has greatly reduced the stability of the austenitic phase, so that a tempering effect has produced the gamma-alpha transformation (accompanied by the precipitation of carbides) resulting in a structure composed probably of some martensite, considerable troostite and some sorbite. Austenitic manganese steel is retained at the top of the photomicrograph, since here carbon diffusion has not been so pronounced.

Nickel manganese welds have a tendency to boil considerably more than straight manganese welds. This boiling action generally results in porosity. By slight weaving or puddling a dense deposit is usually readily obtained. In welding a straight narrow bead the arc should not be advanced too rapidly.

High manganese steel, if properly produced and heat treated, is austenitic; that is, the iron present is gamma iron. Gamma iron can dissolve a considerable amount of carbides; alpha iron (the sort of iron present in low carbon steel) can dissolve only a very small amount. Therefore, if the manganese

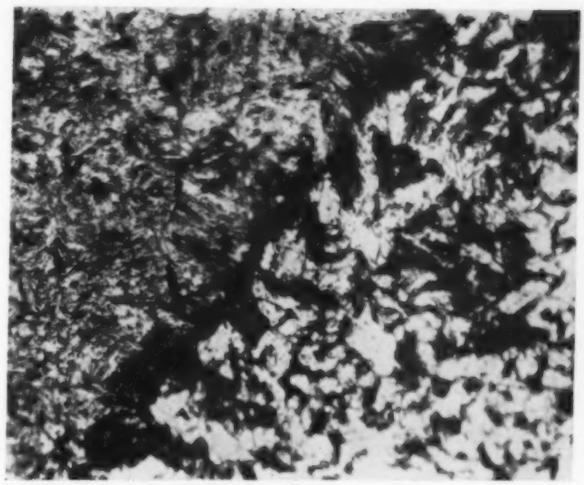


Figure 2 600 Magnifications:
Junction between nickel manganese steel and low carbon steel plate. To the left of the junction there is a zone of martensite typical of martensitic nickel steels. Here carbon diffusion has taken place as in Fig. 1, but the nickel has so retarded the transformation on tempering that no troostite or sorbite appear. This is illustrative of the beneficial result of the addition of nickel.

steel, because of some unfavorable treatment, is no longer austenitic, carbides are precipitated from solution. The austenitic phase, if properly developed, is stable at room temperatures, but at higher temperatures where tempering takes place, there is a partial reversion to, let us say, the martensitic phase and carbides begin to precipitate. In order to redissolve the carbides, it is necessary to heat to a temperature above the critical range and to quench rapidly from that temperature.

Consideration of the act of welding on a piece of manganese steel gives rise to the following thoughts: at a given instant, weld metal is molten, fusion zone is molten, parent metal is at temperatures respectively above the critical range, in the critical range, in the tempering range and in a range negligibly elevated, as sections increasingly farther from the weld are considered. When, therefore, the weld and parent metal are quenched, certain parts become austenitic, others retain partial austenite and precipitated carbide, while still others are unaffected by the entire welding processs. Those parts in which austenite is but partially retained and in which carbides precipitate are responsible for the brittleness and cracking so often observed in the welding of manganese steel.

As already mentioned, the effect of nickel in the manganese steel weld metal is very beneficial because it causes the alloy to be air-toughening; that is to say, austenite is produced by simple process of cooling in air from above the critical range. The nickel of the weld metal furthermore tends to diffuse through the joint, thus improving the quality of the joint and of the parent metal near the joint. And, of course, nickel has its usual additional effect of promoting such desirable properties as ductility and toughness. However, insofar as manganese steel is primarily concerned, the most important fact is that nickel, introduced by deposition and diffusion, promotes stability of the austenitic phase, thereby de-

creasing the likelihood of brittlenesss, excessive hardness and consequent cracking.

Attention is directed to the accompanying photomicrographs. Figure 1 shows the junction between manganese steel weld metal and low carbon steel. Figure 2 shows the junction between nickel manganese weld metal and low carbon steel. Figure 3 shows the junction between straight manganese steel weld metal and straight manganese steel base. Figure 4 shows a similar junction, except that the weld metal has about 3 per cent nickel.

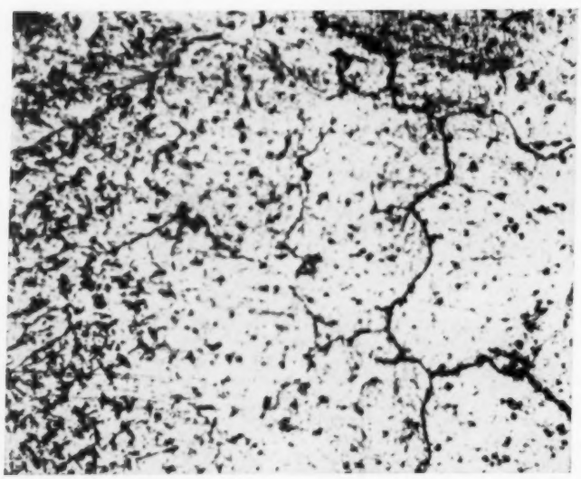


Figure 3 150 Magnifications:

Junction between manganese rod weld metal and straight manganese steel. The welding operation has caused widespread carbide precipitation in both parent and weld metal. (Weld metal on left, parent metal on right.) A condition such as this is responsible for the brittleness and hardness which are common in ordinary welding of manganese steel.

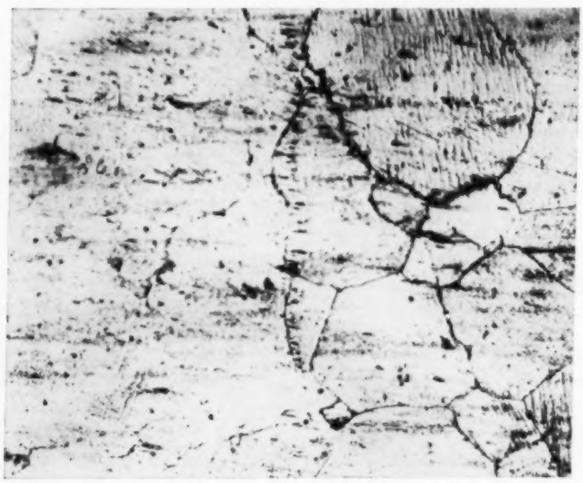


Figure 4 150 Magnifications:

Junction between nickel manganese weld metal and straight manganese steel. The effect of 3% nickel has been to retard carbide precipitation in the weld metal and (by diffusion) in the parent metal. Thus excessive hardness and brittleness are to a large extent eliminated.

A recent development in the repair and resurfacing of high manganese steel parts, which has given excellent results, is the use of the 18-8 types of stainless steel coated welding rods as an intermediate layer between the casting and the final wear resisting surface with high manganese welding rods. Photomicrographs of the junction between the stainless steel weld and the high manganese casting show virtually no penetration into the base metal and bear a strong resemblance to the junction resulting from abrasive operation. In other words, the stainless steel has less penetration than the manganese steel welding rod, so there is a tendency for the molten metal to spread out or build up depending on the amount of current used.

Another advantage claimed for this method is that surface cracks which are fairly common in manganese steel are sealed effectively by the chrome nickel alloy. Due to the higher ductility of the chrome nickel, these cracks cannot spread to the nickel manganese deposits. This method has been adopted by several large operating companies and while too recent to recommend it as standard practice, it seems to possess some real advantages.

Use of alloy ingredients in the coating of the welding rods is preferable to high manganese alloy rods because it is a well known fact that in melting alloy steel there is a considerable loss of manganese and carbon. Obviously, if the welding rod does not contain these alloy ingredients, in excess, the deposited metal will most likely be of inferior quality.

Another advantage in actual welding with coated welding rods is due to the fact that heavy refractory coating on the welding rod concentrates the heat so that it is possible to use lower current, which is an acknowledged advantage in high manganese welding.

In summing up the application of manganese steel welding with nickel manganese welding rods, the recommended procedure may be stated as follows:

(a) The surface to be welded should be thoroughly cleaned and free from oil and rust.

(b) Use the lowest current and the shortest arc which will give stable and easy operating conditions.

(c) Weld only short beads, 3 to 5 inches long and about ⅝" wide and peen the weld thoroughly with a 3 to 4 lb. hammer before proceeding with the next bead.

(d) Use coated welding rods to reduce current required.

The author wishes to thank Mr. G. E. Durham, Metallurgist, Una Welding, Inc. for the generous assistance with photomicrographs and other technical details.

Utilization, Research, and Economies In The Use of Fuels

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Physical and chemical research are on the alert for the cheapest and best ways of using such fuels as nature or art provide us.

While physicists may be speculating on the atomic energy contained in a spoonful of water as being sufficient to drive an Atlantic liner to Europe and back, the engineer is concerned with immediate efficient utilization of available fuels. The engineer's efforts are directed to convert as much as possible of the heat energy of fuel into useful work. The efficiency of various plants and fuels vary widely, as in the case of steam boilers, or diesel engines, or gas producers and gas engines. It is difficult to correlate consumptions for plants of different type under every day conditions of load.

MARTIN J. CONWAY

In general, the consumption per horse power generated is least if the plant is operated at maximum output. In speaking of overall efficiency, both boiler and prime mover, or in the case of gaseous fuels, both producer and gas engines are considered.

The proper control of the combustion process regulates minimum consumption of fuel with the output of power. With internal combustion engines, the increase in size produces proportionately less energy than with steam plant. Data are available showing the percentage of thermal efficiency of various types of engines, such as diesel, large gas engines, large turbine sets, high speed reciprocating, uniflow, and ordinary expansion condensing and non-condensing reciprocating engines; and in general, the self contained diesel plant will show the highest rate of thermal efficiency, with the small non-condensing reciprocating engine showing the lowest rate of thermal efficiency. It naturally is futile to preseat the complete tables showing fuel consumption at various loads of these types of engines, or the overall consumption of fuel per horse power at full load under running condition, as a perusal of your text books will show overall relative efficiencies of 2.5 to 1.

In general, the gas producer shows a higher thermal efficiency than boiler operation; responding more readily to changing demands and requiring less fuel, there being less material to heat up and necessarily less radiation losses.

Low grade coals and lignites can be economically gasified. Maximum consumption per horse power hour has been computed for 138 grades of bituminous and semi-bituminous coals and lignites. In gas producers, using the resultant gas in gas engines, as compared with water tube boilers and reciprocating steam engines, the comparison is always favorable toward the gas engine as regards fuel consumption. But fuel economy is not the sole consideration, for we must determine the kind of plant suitable for power production under the varying conditions of practice demands. Cost of installation, geography of location, fuel charges, and operating cost must be taken into account in selecting a suitable system, and, after full consideration has been given to plant, weight and space, the choice made which produces the lowest power cost over a long period of time.

There are various unusual power installations, such as mercury vapor boilers, instead of steam, some of which are highly effective. However, the present cost of mercury makes their general use prohibitive, but, we are concerned, in the main, with fuels rather than mechanisms, and hence, practical considerations must prevail. Undoubtedly the advantages of liquid and gas fuels are great, and while taking into consideration the many advances made in engine design, and discovery of new oil and gas reserves, either in natural form or recovered from shale, coal still predominates.

The coal industry plays such a vital part in the industrial activities of the nation, and is so closely interlinked with our general prosperity; and our coal resources contribute so much to our national assets, that the wonder is that its many problems have not been the subject of research and direction on organized and scientific lines.

The problems of fuel economy may be pursued from three different angles: First, there is the economy to be obtained from existing plants now in actual operation; second, the economy resulting from

the development of the use of electricity; thirdly, there is the future development of fuels such as the new uses and treatments of coal, oil and the elements. These may again be divided into two sections; the domestic, and the industrial. These are the directions in which the fuel technicians of today can most usefully conduct their inquiries, and assist the various industries of this country and the community at large.

There is no reason to fear a fuel shortage as substantially 60 per cent of the known fuel deposits in the world are to be found in North America, but the economics of distribution and utilization are not by any means practiced. A striking example of this is the fact that the cost of one ton of bituminous coal f. o. b. dealers' yards in Philadelphia does not exceed, in many cases, the difference in price between anthracite coal f. o. b. dealers' yards and the price paid delivered to the household consumers. In other words, the eastern coal dealer obtains twice as much for handling one ton of anthracite coal after he has received it, as the bituminous coal company receives for two tons of bituminous coal f. o. b. cars their mines. These differences in apparent values may be justified in the present order of things but they are economically unsound and point the way to large savings in the employment of improved distribution methods.

Public Utilities can claim much better economies in the distribution of their products than can the coal industry, and, during the past few years have effected the greatest strides in fuel economy in America. Progress has been made, not only through the better design and operation of equipment, but also by the shutting down of small, obsolete plants and by the interlocking of various large plants into one common system, thereby improving the general load factor. The interlocking of steam and hydro-electric stations, and the tying together of one company operating in one district, with another company operating in another district, is proceeding at rapid rate, particularly in the north eastern states.

Long distance electrical transmission lines of the north eastern section of the country have been so tied in between Boston and Chicago that there is a continuous system of transmission lines for nine hundred miles.

Large steam stations, operating along the Atlantic Coast with the plentiful supply of condensing water, and with low fuel freight rates, have been connected with hydro-electric power plants, located on the northern rivers, thus eliminating the necessity for small, inefficient power plants at intermediate points.

In the future utilization of fuel and its by-products, we have the fact, that the problem of increasing the hydrogen content of coal thereby converting it into oil, is already solved, and its full exploitation in this country is merely a matter of time and necessity.

In by-product recovery we have sometimes been accused of national lethargy, but here, again, progress has been made, and we may look forward in a few years to substantial returns in this direction.

The vast range of fuel technology in domestic use is too frequently under-estimated, sometimes almost ignored. The question of heating buildings, the proper appliances to use for this purpose, the smoke nuisance, and so on, are among the problems which effect every member of the community.

Furnace efficiency is usually attained at the cost of maximum fuel efficiency. High fuel costs may be balanced by cheap installations for temporary purposes, but for permanent straight line results, fuel efficiency and furnace design must be considered together for best performance. Even in the best furnaces the heat losses exceed 15 per cent of total heat input. The highest possible efficiency can only be attained through serious effort and the calculation of heat balances.

Complete characteristics of a furnace can be readily computed, there being a number of well known factors that contribute to heat losses and by thorough study, improvement is usually possible. There are stack losses of sensible, potential, and latent heat of water vapor; losses of sensible and undeveloped heat in the ash, and radiation losses. Stack losses vary from 10 to 40 per cent depending on the temperature and analysis of the flue gas, especially where carbon monoxide, hydrogen, methane, or soot are present. An increase of combustion air increases the sensible heat loss, while it lessens the loss due to unconsumed fuel. Minus .5 per cent of CO is usually an indicator of the point of maximum efficiency all other factors being equal.

The heat balance data must take into consideration the different types of combustion devices, where the fuel is burnt directly for heating purposes as in boiler furnaces, heating and heat treating furnaces, open hearths, blast furnaces, and all types of kilns, and secondly, the preliminary furnaces, such as gas producers, water gas, and oil gas sets, coke ovens, and similar devices.

Losses on hand fired boilers are considerable, never under 20 per cent and often 40 to 50 per cent. These losses consisting of high excess air, poor mixing, air infiltration through the settings, inefficient firing methods, improper damper regulation, and so on. Tests on large modern boiler installations in public utility and industrial plants convince one that efficiencies of 80 to 85 per cent are not difficult to obtain with the use of proper heat recovery devices. Excess air should be reduced to a minimum in relation to the fuel consumed, for the sake of an optimum ratio under all conditions of operation, whether for brick kilns, metal melting and treating furnaces, or steam boiler furnaces.

The consumption of coal is roughly divided by industries as follows:

	%
Industrial boilers	30.2
Railroads	25.0
Domestic consumers	16.6
Metallurgical Coke	13.1
Public Utilities	4.9
Export	4.3
Heat & Power at Mines	3.3
Bunker Fuel	1.6
Manufactured Gas	1.0
	100.0

PUBLIC UTILITIES

Public Utilities have probably made the greatest strides in fuel economy during the present century. The average consumption being 6.9 pounds of coal per K. W. hour in 1900 as against less than 2 pounds per K. W. hour in 1930 with some stations slightly over 1 pound per K. W. hour.

The universal adoption of automatic combustion control has contributed largely to these better results and has made possible the maintenance of monthly operating efficiencies very closely approaching the efficiencies found on test. The effect of this improvement has varied with the various plants, but the average results obtained by use of automatic combustion control, are seldom less than 2 per cent saving.

While electrical energy consumption has been increasing at the rate of approximately 5 per cent per capita since 1900, the total fuel consumption used in its generation has not materially changed.

STEEL INDUSTRY

Constant improvement is being made in the operation of the several fuel consuming units, notably in blast furnace practice where daily tonnages in excess of 800 tons are not considered records, but much remains to be done.

The keystone of fuel economy in any composite plant is the blast furnace, which must be regarded not only as a producer of iron, but also as a producer of gas. Ideal fuel economy will be reached, when no coal other than that necessary for the manufacture of coke is used. To achieve this, means, that the total of the blast furnace gas must be utilized to a greater degree of efficiency than present average practice, and that the maximum number of heat units, contained in this gas must be converted into other forms of energy. The fundamental basis of economy in the use of blast furnace gas is the gas engine, with exhaust heat recovery for both blowing and power generation purposes, its use resulting in a greater percentage of surplus gas becoming available for other purposes.

The installation of large modern gas engines for power production, combined with the complete and efficient utilization of this greater amount of surplus gas in the steel furnaces, accompanied by refinements in the design and operations of blast furnace stoves and heating furnaces, as well as the use of clean gas, is the direction in which fuel economy will be sought.

Mixtures of coke oven and blast furnace gases are used successfully in heating and melting operations, luminosity being furnished by the use of a small quantity of tar or oil where required. From this point of view of ultimate economy, steel plant engineers should be guided by the principle, that blast furnace and coke oven gas be applied, primarily, to all uses where solid fuel cannot be utilized, and subsequently only to those uses where solid fuel can give equally good or even better results, particularly under boilers. It is not economical to use blast furnace gas or coke oven gas under boilers, except as a relief valve for surplus, because coke breeze and the cheaper grades of fuel used in the pulverized state, or on modern stokers, would give equally good results, while at the same time, gasifying more expensive coal for use in heating and melting furnaces, for which purpose blast furnace gas mixed with coke oven gas could be employed to greater advantage. It being borne in mind that the use of blast furnace gas and coke oven gas when used in melting and heating furnaces, saves the cost of gasifying an equivalent amount of high priced coal.

In good blast furnace practice 25 per cent of the total output of gas is required for heating the blast. If gas engines are used for blowing and power generation, 18 to 20 per cent of the total gas output will be required for blowing, and miscellaneous power required by the furnace plant, as against 40 per cent with most steam installations. There remains 50 per cent of the total gas as surplus in the case of the gas engine, and 30 per cent in the case of steam driven plant, this after due allowance for gas loss in both cases.

The modern gas engine has been well developed, there being units of 11,000 horse power driving 8,000 K. W. generators, operating at nearly 40 per cent efficiency.

The cost of cleaning additional gas for the gas engine involves but a small extra cost, as it is fully realized in modern practice, that the whole of the gas must be cleaned if the best results are to be obtained in other uses.

Waste heat boilers should be installed, where possible, to be operated in batteries, as at the open hearth plant, and, there is a definite trend toward fire tube design for this work, because of their greater efficiency, since air infiltration is minimized and the tubes are easier to clean.

Improved regenerator and recuperator design are effecting economies of 100 per cent over previous practice and heating furnaces of all kinds are receiving their share of improved engineering thought.

Among the fuels commonly used in the open hearth process, probably the most interesting to the fuel engineer, is liquid fuel—coal tar or oil. Coal tar is not commonly used, except where economic reasons force its use as a fuel, but the residual oils from refining operations can be used advantageously as open hearth fuels, either alone, or mixed with gases. Fuel oil is usually purchased by the gallon, and for that reason the lower the Baume or heavier the oil, the greater the calorific value per gallon.

The success of oil as an open hearth fuel depends on correct atomization, constant pressure and temperature and intimate mixture of the atomized oil with the combustion air. The oil temperature required to produce the viscosity suited for correct atomization is seldom more than 160°F. it being unnecessary to heat the oil above this temperature as little drop in viscosity is obtained. Compared with coal as producer gas, gasification and soot losses are eliminated, and checker life is increased, together with increased furnace life and heat input more easily controlled. The open hearth furnace has been the subject of a great deal of study during the past ten years; automatic combustion control has been applied with success, and we may look for greater economies in this direction during the next few years, than in any other section of steel manufacture.

OIL REFINERIES

The modern oil refinery is a large user of fuel, many refineries using in excess of a million dollars worth of fuel per year. In times past, cracking coil furnaces were fired with a large excess of air, in order to prevent burning out of the first row of tubes, their being exposed directly to the radiant heat of the fire. Today, a small excess of air is used, and combustion takes place in carborundum muffles which absorb heat from the gases at their higher temperatures, and then radiate it to the coils at a temperature lower than the flame temperature of the fuel, but yet sufficiently high for still operation.

More efficient use of refinery gases and wastes are being made, refinery sludge is being fed as fuel to the boilers and atomized with almost the same ease as heavy fuel oil. Waste gases are being compressed and sold in liquid form for industrial and domestic use. These new products bring the luxury of the city home to the isolated farm, and the small industry is becoming independent of the public utility, as, for a small investment, it can manufacture its own gas for process work for about one-half of the cost of the gas supplied by the local gas company.

During the past few years, transportation of refinery products has undergone great changes. For short distances up to 75 miles the tank wagon and trailer have given to the smaller industry and large hotel and apartment house, the facilities of bulk delivery of fuel oil, allowing them to enjoy the same savings as if they were directly connected with railroad sidings. From 75 to 400 miles and upwards, gasoline and light oils are being distributed by pipe line, at a transportation cost reduction varying with distance, of from 14 to 50 per cent of railroad freight and with greater safety and cleanliness in handling.

PULVERIZED COAL

Pulverized coal permits of a wider range of fuels in a given installation, with the use of high ash and moisture content fuel that cannot be used at such economies on stoker fired installations. While comparatively new, this system has been the means of added impetus to improvement of design in stoker fired installations, with the result, that gross efficiencies of close to 90 per cent are obtainable in some of the larger stations. There has been a marked reduction in the necessary furnace volume required for pulverized coal firing, which has been brought about by air cooled and water cooled walls, together with increased turbulence within the furnace, with the result that while less than ten years ago, the then efficient units liberated between 10,000 and 15,000 B.t.u.'s per cubic foot of furnace volume per hour; 40,000 to 60,000 B.t.u.'s are released in the average installation today, with the latest designs showing liberations as high as 100,000 B.t.u.'s per cubic foot per hour. Notable results have been obtained by the proper applications to almost all types of boilers including locomotives.

In the case of locomotive firing, the firemen find it difficult to control the irregularities of slack and lump coal proportions in hand firing. Whereas with powdered coal this difficulty is eliminated and combustion is practically smokeless, and, based on hand firing, savings up to 25 per cent have been obtained. Ash can be removed readily. There are no grates to clinker after forced operation and the boilers can take care of peak loads with the flexibility of fuel oil. Besides which, wide variation in quality of coals is tolerated, most grades being burned with economy. Locomotives can be readily adapted to such combustion and give some of the ease of manipulation and speed of response of the electric locomotive. For steam boiler furnaces, Dr. C. H. Lander first suggested the principle of the vortex combustion chamber, in which the air travels from circumference to the center of a cylindrical chamber, in which vortex motion has been established. The effect is equivalent to a stationary cylindrical fuel bed through which air travels radially. Air supply is adjusted to make the burner operate as a producer. Coal ash will not fuse, nor brickwork be affected.

By means of the Grid Burner, fuel is suspended in thin parallel streams of preheated air, and secondary air is introduced with air carrying the fuel. A burner having an area of nine inches by nine, burning from 400 to 1,400 pounds of coal per hour with a maximum flame length of eleven feet.

In the past fifteen years, many claims have been made for the economical and efficient operation of powdered coal. One can become an ardent advocate of any fuel system, for all fuels have their disadvantages as well as their merits. There is a wide variation in the properties of coal, and the right kind must be applied to the purpose under consideration. The secret of successful burning depends on the design of the combustion chamber or furnace. The increased investment of plant over conventional stoker fired plant usually afford a saving which will return the investment in four years.

The successful application of pulverized coal firing to cement kilns, heating furnaces, malleable iron furnaces and the like are already well known, and a few instances where overall cost justifies the application to open hearth furnaces.

THERMAL INSULATION

Within the last few years, the question of thermal insulating as applied to furnaces in which a high temperature is generated, has received serious consideration, yet the magnitude of the fuel saving which can be effected by its means has not been properly appreciated by many, together with the subsidiary economies and advantages which accrue.

The importance of insulating steam lines has, of course, been appreciated for sometime and attempts have been made in certain of the older types of high-temperature equipment, such as kilns and brick furnaces, to conserve heat by building very thick walls. This practice defeats to a great extent its own object.

When a high temperature is generated in a furnace, heat flows by conduction through the walls to the outer surface, from whence it is dissipated to the atmosphere or surrounding bodies by radiation, and the amount of heat conducted must be equal to that dissipated, and vice versa; thus, the factors which govern the flow of heat by each of the three methods of propagation—conduction, radiation, and convection, are all operative in affecting the heat losses from a furnace or similar structure.

By use of suitable insulating materials, radiation losses can, in most cases, be reduced by 75 per cent.

LOW TEMPERATURE CARBONIZATION

When one ton of a suitable coal is distilled at low temperature, there remains 1,440 pounds of solid fuel, while the gas yield amounts to some 3,500 or more cubic feet, having a calorific value of from 850 to 950 B.t.u.'s per cubic foot. From this gas, about 2½ to 3 gallons of light spirit suitable for the manufacture of motor fuel can be recovered by means of scrubbing; and in addition, from 25 to 30 gallons of light tar are yielded directly, having a calorific value of from 16,000 to 16,500 B.t.u.'s per pound and an additional quantity of motor fuel can also be obtained from this tar.

That there is an increasing realization of the extent of the field which would be available for free burning cokes has been clearly indicated during the past few years by a widespread interest in their possible production, shown alike by scientists, technical men and the general public.

Coal is a highly complex substance, and the nature of products resulting from its thermal decomposition varies not only with the particular type of coal, but also with the degree to which its temperature is raised and the extent to which the period of heating is prolonged. It is well known that the difficulties met with in the carbonization of coal are magnified when the heating of the retorts is limited, as in low temperature methods, to 600° C. or thereabout.

In high temperature gas manufacturing processes, where the main desideratum is a maximum yield of gas of the "standard" calorific value, and where the recovery of coke, tar, etc., is regarded as of secondary importance, neither extreme temperatures nor prolonged heating of the retorts have any serious consequences to the main product, and both are, in fact, generally considered desirable, because extreme temperatures reduce the tar yield and consequently increase the gas yield. But, in low temperature processes, where the triple requirements of smokeless fuel of certain defined properties, the maximum possible yield of light oil and tar, together with the production of a high calorific value gas must be fulfilled, it is essential that the heating should be carried only to such a point as will give the desired products, which must be released before they have had time to suffer decomposition through too prolonged exposure to the heat inside the retort. About 700° C. may be considered as the limit beyond which the coal should not be heated if the oils and gases are to possess the properties associated with the primary products of carbonization. As coal and its products are poor conductors of heat, the success of low temperature methods, especially in regard to the manufacture of a homogenous coke, demands either that the period of carbonization be prolonged, or that the coal should be exposed to the heating process in comparatively thin layers.

The structure of a coke is chiefly dependent upon the caking characteristics of the coal or blend from which it is prepared, but the temperature of carbonization, and the size to which the coal is broken down entering the process also affect the physical nature of the resultant coke.

The combustibility of a coke is intimately bound up with both its chemical and physical properties. As regards chemical properties, it has been shown that the volatile content is at least a controlling factor in the ease both of ignition and subsequent combustion, for cokes which are essentially similar, except in regard to the proportion of volatile matter which remains in them, behave differently in these respects.

For this reason the 9 to 12 per cent of volatiles which low temperature cokes contain, as against 1 to 3 per cent of high temperature cokes, may be expected to weigh strongly in their favor when offered for domestic consumption. From the point of view of physical properties, experimental work has amply demonstrated the important consequences of the structure of the coke upon its combustibility, and has shown that one of the main factors involved is the aggregate porosity area of its internal cell surfaces, which it is desirable should be as large and accessible as possible, in order that an extended surface may be presented to the action of gaseous reagents.

The gas produced by low temperature carbonization of coal is an excellent fuel for the heat treatment of steel or domestic purposes.

Throughout the country there are industries, large and small, which, from a fuel point of view, could be run much more efficiently with but little more effort and attention. The habit of fuel saving for its own sake would, in the aggregate, have a tremendous effect on our national economics.

Centralization of gasification processes in industrial areas, is as necessary to the economics of industry as the centralization of power plants for the generation of electricity. Such centralization will produce a high grade smokeless domestic fuel; a light oil which is almost entirely non-aromatic, but containing cyclic saturated and unsaturated hydro-carbons, high in anti-knock value when used as a motor fuel; a light tar containing 25 per cent by weight of phenols but with napthalene, anthracene and their related products absent, and, a gas which is almost similar to natural gas in chemical composition and thermal value. Because of its low basic cost and ease of control, clean rich gas will remain the logical fuel for large heat treating operations for many years.

COLLOIDAL FUEL.

Coal and oil combinations unite the merits of both fuels, for the physical property of fluidity can be conferred upon solid coal when powdered and mixed as a colloidal amalgamation. In 1920 it was known to be possible to amalgamate no less than 55 per cent of triturated coal with oil. Fuels containing somewhat less proportions of coal have been successfully used.

The advantages of such fuel has long been known, for it is practically non-volatile, the flash point being usually higher than that of ordinary fuel oils, the material showing no tendency to spontaneous ignition. Inasmuch as the specific gravity is greater than water, it can be readily quenched in case of fire and stored under water.

The mixture is homogeneous for several months in storage. A gallon of colloidal fuel contains more heat units than fuel oil. This is a consideration in marine use, where bulk of cargo is an important consideration. Colloidal liquid fuel contains nearly twice the amount of heat units per cubic foot of fuel as does powdered coal, thus giving to vessels increased bunker capacity or a wider cruising radius. It is one of those fuels which fit special needs only, as in most cases its cost is prohibitive on a straight heat unit basis.

Various attempts have been successfully made to amalgamate the carbon from high ash coals with oil to make a solid fuel. While the resultant fuel is excellent and the waste coal reclaimed, the cost of the finished fuel is not at present generally competitive.

HYDROGENATION

The fact that coal can be converted into oil has been known for a considerable time, but the early methods employed expensive chemicals and were regarded as interesting scientific exhibits. It was not until Bergius, in 1912, demonstrated that coal could be converted into oil by the action of gas hydrogen under certain conditions of heat and pressure, that the matter began to have the least practical importance. Bituminous coal consists essentially of carbon, hydrogen, and oxygen with small quantities of nitrogen, sulphur and other bodies. The hydrogen contents of bituminous coals range chiefly between 4.5 to 5.5 per cent and for rough calculations we may safely assume that the available hydrogen in coal, over and above that necessary to combine with the oxygen of the coal, is of the order of 5 per cent. Mineral oil is much richer in hydrogen, containing some 14 to 15 per cent, compared with the lower figure found in coal. Clearly, then, to convert coal into something resembling mineral oil, necessitates the addition of about 10 per cent of hydrogen to the weight of the coal processed.

High pressure hydrogenation is now an established and economic fact. One hundred tons of pulverized coal, mixed with oil and treated in a converter in the presence of hydrogen at 450° C. and 3,500 pounds pressure, produces 62 tons of gasoline, 28 tons of gas, plus a carbonaceous residual. Low pressure hydrogenation, while not yet successfully commercialized is capable of producing like results using heavy fuel oils and tars as the products to be treated and at a lower initial plant cost, the resultant gasolines are high in anti-knock values and are at present being used for blending purposes.

Bergius experimented with coal tar and petroleum residuals and especially with coal paste made with residual oil, subjecting them to a hydrogenation process, light hydro-carbons being obtained from heavy ones on heating and subjection to hydrogen under pressure.

By-Product coke oven light oil can supply but a small proportion of motor fuel demands, whereas tar distillates give a relatively colorless liquid after treatments. These distillates are of high anti-knock quality and are useful as a binder and blending material with gasoline. In Great Britain, the tars obtained from coal gas and coke oven plants are the most promising source of supply, and the latest Diesel engines are capable of utilizing these heavy tar oils, so that a very extended use of such products is indicated in other countries where oil is not plentiful.

As one-half of one pound of tar will produce one horsepower in properly designed internal combustion engines, the tar oils produced from the 52,000,000 tons of coal coked in by-product oven and gas plants annually is a potential source of fuel for these engines if necessary.

INSTRUMENTS

The lines along which industry has developed during the present century have emphasized the necessity of the measurement of all factors which govern the various processes of manufacture. In the early days of industry, when the workers had to depend on imperfect tools, methods of manufacture which were not properly understood, and raw materials irregular in quality and imperfectly prepared for manufacture, the skill of the worker was of paramount importance.

With the human eye as the only instrument available and the personal experience of the worker as the only source of information, mistaken judgment on the part of the craftsmen could disrupt the whole working of the process. Any technical progress which was made was consequently more a result of accident than skill. As competition increased, the first desire of the manufacturer was to be able to meet the demands of his customers for a more uniform product with a minimum of waste. This necessitated rough instruments being devised and arbitrary tests being used to assist the worker in obtaining reproducible results, and to prove to the customer that the quality of the product was similar to his previous shipment.

The increased demand for cheap materials which has led up to the present day mass production methods, by increasing the size of the industrial plants, has necessitated the adoption of methods of scientific control for all industrial operations.

Fuel being one of the largest items on the cost sheet, naturally received first attention and this laid the foundation for the intensive fuel economy campaign which has taken place during the last 30 years.

It is not so long since that a pressure gauge was the only instrument in the steam plant, just as the shovel was the principal tool. Today steam plant performance and efficiency is practically a measure of the number and application of instruments installed. In the steel industry, a few years ago the heat treating department and laboratory were the only instrument locations in the plant, and then were more or less viewed with awe, by the uninitiated employee and manager alike. Today, the need of measuring devices is recognized in every department of the plant engaged in the making, shaping, and treating of steel.

The first step towards the scientific control of a heat exchange system, is the preparation of a heat balance including those items which can actually be measured. The remaining items should, if possible be calculated, otherwise determined by difference. From this proximate balance it will be possible to determine the relative importance of the factors which are not measured, and this will serve as a useful basis for the choice of instruments and measuring devices.

A balance sheet, based as it is on the fuel consumption of the process, requires a complete knowledge of the fuel characteristics, such as B.t.u. value, analysis and weight, and at once shows the importance of specifying the fuel consumption, not in pounds of coal or gallons of oil per ton of product, which, stand-

ing by itself is a meaningless expression, but as the actual heat consumption, in either B.t.u.'s or therms per unit of product.

A unit of this type is not only applicable to all stages of the heat balance, but also makes it possible to obtain a true comparison between the relative efficiencies of several types of fuel.

A consideration of the use of instruments will show that for industrial furnace practice they fall into three groups, depending on the use to which they are put.

(1) Instruments which are essentially required for the successful operation of the furnace. These may frequently be instruments which measure the results of one or more variables, but these variables having been found by experience to give an insight into the operation of the plant, have been adopted as necessary instruments to assist the operator. Instruments of this type are usually indicating only.

(2) Instruments which are necessary for recording the factors which directly affect the cost sheet, which record fuel consumptions and those variables which are an index to the efficient operation of the plant. These instruments are used for administration record purposes and must of necessity be recording instruments.

(3) In this group are placed the instruments which are incorporated either temporarily or permanently in the plant entirely for the sake of research work. Included are those instruments which are used solely for completing the thermal balance of the system, in addition to investigating the factors which up to the present have not received full consideration.

These latter instruments, as they take no part in the daily production routine, and show no direct financial return for the capital invested, are apt to be unwanted and difficult to justify, in spite of the fact that it is only by the use of such instruments that rapid progress in design and operation of open hearth and similar furnaces can be attained.

Important as it is to employ the various recording and other instruments now available, these are of very little use unless full advantage be taken of them. Disappointing results obtained can usually be attributed to failure to understand the lesson taught by the instrument readings, and, or because of, the absence of the trained personnel to point out such lessons and to apply the teaching.

As an example, high temperature of the flue gases of a boiler may be due to dirty tubes—either scale on the inside or soot on the outside—leaking baffles, or overloading.

Circumstances will point the reason and fix the responsibility.

Before installing any instruments, the advisability of their use and probability of success must be fully considered. Whereas a CO_2 recorder installed to show the composition of boiler flue gas is of great value, such a device attached to a reheating furnace will be practically useless, where the effect of air drawn in at the doors while charging and discharging is sufficient to confuse the issue.

Measurement of the amount of fuel used in all furnaces must be made if accurate control in any form is to be made. Furnace design governs the maximum temperature obtainable, and, any fuel added in excess cannot cause further heat exchange and must therefore be wasted.

From gas producer to pickling tank, through the steam plant, soaking pits, melting and heating furnaces to the smallest auxiliary, indicating and recording instruments are as necessary to economical use of fuel as the scales in the shipping department are necessary for the correct weight to the customer; both measure performance. The company having the proper equipment to measure their entire process, backed up with an intelligent recognition of the necessary care and maintenance of these instruments, will gain a substantial return in proportion to their investment.

DEVELOPMENT

Much economy has been effected recently by the better utilization of the steam locomotive and this has permitted extensive scrapping of types long obsolete and inefficient. The most striking development in the use of fuel on railroads has been the emergence of the oil engine or so-called Diesel locomotive from the experimental stage into the realm of practical railway politics.

The mere fuel economy of the oil engine as compared with the steam driven locomotive is well known, but the oil engine introduces entirely new conceptions into railroad operation and requires a new conception of means and procedure from the traffic department as well as from the mechanical and engineering departments.

That we can look for great changes and developments in this direction is certain. Liquidation of first cost of units is possible in five years with passenger train costs carrying 300 persons, as low as 20 cents per train mile.

The Diesel engine has, accepted high standards in marine work, using heavy residual oils as fuels and fitted with waste heat boilers, these units have a record of performance and ease of upkeep and handling which our merchant marine cannot afford long to ignore.

Large and medium sized generating units for industrial power uses are being considered for land use that have efficiencies of from 35 to 40 per cent delivered to the crankshaft.

Two developments which are giving the petroleum industry greater flexibility is the hydrogenation of oils from coal and the development of the compression ignition engine. We have a surplus of heavy residual oils which form the basis of such hydrogenation, and such as may be utilized in the Diesel type engine.

Furthermore, it is now definitely known that our liquid fuel resources are sufficient for at least two generations, and, through the combined efforts and research of the two fuel industries—solid and liquid, we can confidently look forward to a new era in the utilization of fuels.

ITEMS OF INTEREST

PERSONNEL CHANGES

▲

Ralph H. Watson, vice president in charge of operations, Carnegie Steel Co., Pittsburgh, since Sept. 1, 1930, has been appointed vice president in charge of operations of manufacturing interests of the United States Steel Corpn., with headquarters at 71 Broadway, New York. He joined the Carnegie Steel Co. in March, 1902, as a metallurgist's assistant at the Homestead Steel works.

▲

James E. Lose, general superintendent Homestead Steel Works, Carnegie Steel Co., Pittsburgh, has been made vice president in charge of operations for the Carnegie company, succeeding Ralph H. Watson. Malcolm F. McConnell, who has been general superintendent at the Mingo, Ohio, works of the Carnegie cimpany, has been named to succeed Mr. Lose at Homestead. Robert S. Quinn has been made general superintendent of Mingo works, and Hugh B. Conover, assistant general superintendent.

▲

W. C. Reilly, vice president, Youngstown Sheet & Tube Co., has retired from the operating department to become associated with the president's office in charge of development and general research. He has been connected with the company for about 33 years, having been associated with the former president, James A. Campbell.

W. B. Gillies, assistant vice president of the company, for the past four years, succeeds Mr. Reilly as vice president in charge of operations. Mr. Gillies' affiliation with the company began in 1923, when it purchased the Steel & Tube Co. of America, with which he was formerly associated.

▲

Sterling Electric Motors, Inc. of Los Angeles have appointed Edgar M. Moore & Co., Farmers Bank Bldg., Pittsburgh, Pa. as Sales Representative for western Pennsylvania, eastern Ohio and West Virginia.

▲

L. W. Grothaus, who has served as general representative, in charge of the sales organization, of the Allis-Chalmers Mfg. Co., Milwaukee, has been appointed assistant to the president.

Walter Geist, who has been made general representative, has been identified with the company since 1909, in the flour mill, saw mill and power transmission division. He has been assistant manager of the milling machinery department since 1928.

▲

H. C. Thomas, formerly assistant to the general works manager, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been appointed sales manager of the Micarta products for the Westinghouse company. Mr. Thomas has been affiliated with Westinghouse, with the exception of a brief period during the war, since 1910.

▲

The Roller Bearing Company of America located at Trenton, N. J., announce that Pennsylvania State Senator Jos. C. Trainer is now in control of the company.

Mr. Wm. De Vellier has been appointed general manager and the sales will continue under the direction of E. C. Gainsborg.

▲

Homestead Valve Manufacturing Co., Inc., Coraopolis, Pa., have appointed Reeves-McCormick, Inc., 5317 N. Second St., Philadelphia, Penna., as Exclusive Representative covering the Philadelphia District, for the sale of their vapor spray machine used for Automotive, Industrial, Aeronautical, and Building Cleaning.

▲

MECHANICAL DEPARTMENT SETS SAFETY RECORD

Three years without a loss-of-time accident is the unusual record of the mechanical department of the Indiana Harbor works, at East Chicago, Indiana, of The Youngstown Sheet & Tube Co. W. D. Cleavenger is superintendent of the department, where 312 men are employed. This means that 2,276,249 hours were worked without a loss-of-time accident.

W. D. CLEAVENGER

In a letter of congratulation to the personnel of the department, Frank Purnell, President, said that such a record is a tribute of the employees toward safety and justifies the company's efforts to bring about the highest possible degree of safety in working conditions of the plants.

★ *Above is one of five 51″ O. D. Bearings ordered by the E. W. Bliss Co. for the world's largest 4 Hi Cold Mill. These are the largest Mill Bearings ever built.*

The Outside Diameter Tolerance is ±.001″

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HIGH CARBON ELECTRIC ALLOY STEEL FOR ROLLERS AND RACES. **BANTAM** ONE PIECE RIGID BRONZE CAGES

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ASSOCIATION NOTES

On a recent mail ballot, the members of the Association of Iron & Steel Electrical Engineers elected the following officers for the coming year, effective August 1, 1933:

President—W. E. Miller, Elec. & Mech. Supt., Bethlehem Steel Co., Johnstown, Pa.

First Vice President—W. H. Burr, Elec. & Mech. Supt., Lukens Steel Co., Coatesville, Pa.

Second Vice President—J. A. Clauss, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.

Treasurer—G. R. Carroll, Elec. Supt., Jones & Laughlin Steel Corp., Aliquippa, Pa.

Secretary—A. D. Adams, Asst. Supt., Spang Chalfant & Co., Inc., Ambridge, Pa.

Director at Large—A. L. Foell, Chief Engr., Arthur G. McKee Co., Cleveland, Ohio.

Honorary Directors—J. Farrington, Elec. Supt., Wheeling Steel Corp, Steubenville, Ohio; E. Friedlander, Pittsburgh, Pa.

Directors—W. S. Hall, Supt. Engr. & Constr., Illinois Steel Co., S. Chicago, Ill.

F. E. Leahy, Fuel Engr., Youngstown Sheet & Tube Co., Youngstown, Ohio.

J. W. Bates, Elec. Engr. Power Div., American Sheet & Tin Plate Company, Pittsburgh, Pa.

C. C. Pecu, Lubr. Engr., Bethlehem Steel Co., Lackawanna, N. Y.

J. A. Oartel, Safety Director, Carnegie Steel Co., Pittsburgh, Pa.

W. A. Perry, Supt. Elec. & Pwr. Depts., Inland Steel Co., East Chicago, Ind.

W. J. Donahue, Chief Elec., Southern District, Republic Steel Corp., Birmingham, Ala.

C. M. Thompson, Jr., Prod. Engr., Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.

C. A. Thayer, Chief Engr., Republic Steel Corp., Youngstown, Ohio.

Past Presidents—J. D. Donovan, Elec. & Mech. Supt., Republic Steel Corp., Massillon, Ohio.

J. J. Booth, Elec. Supt., National Tube Co., Gary, Ind.

Managing Director—J. F. Kelly, Pittsburgh, Pa.

OBITUARIES

A. A. Stewart, an electrical pioneer in the Iron and Steel Industry and Chief Electrical Engineer of the Pittsburgh Steel Company at Monessen, Pa., died suddenly August 2, 1933.

Mr. Stewart assisted in the installation and operation of the largest electrification applications in the Iron and Steel Industry. These applications were at the Gary Plant of the Illinois Steel Company. Mr. Stewart later accepted a position with the Pittsburgh Steel Company as electrical engineer and was located at Monessen. He contributed many novel and ingenious ideas to the advancement of the application of electricity to the Iron and Steel Industry. He recently completed a valuable contribution to the art of Welding in the Iron and Steel Industry.

A. A. STEWART

Mr. Stewart was a very active member of the Association of Iron and Steel Electrical Engineers and enthusiastically supported all of its activities. He served the Association in various capacities during the last ten years and in 1928-1929 was National Secretary.

Mr. Stewart's death is a great loss and the A. I. & S. E. E. membership extend their sympathies to the associates, friends and family of this highly respected engineer.

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Saul Lavine, formerly sales engineer of the General Electric Co., in the Pittsburgh District, died at Conneaut, Ohio on July 29. Mr. Lavine was widely known throughout the Iron and Steel Industry and enjoyed the confidence and esteem of the electrical profession at large. He was very active in the affairs of the Association of Iron and Steel Electrical Engineers and served on several National Committees. He had contributed many valuable papers and discussions on electrical subjects before the Society and his opinions and experiences were highly respected by the engineering fraternity. Mr. Lavine's death will be deeply felt by his host of friends and the membership of the A. I. & S. E. E. extends their deep sympathy and condolences to the family and friends of this prominent engineer.

SAUL LAVINE